BRIDGING LOCAL AND EXTERNAL KNOWLEDGE FOR DISASTER RISK MANAGEMENT PLANNING: THE PERCEIVED BENEFIT OF PARTICIPATORY 3D MODELLING

IN UMGUNGUNDLOVU DISTRICT MUNICIPALITY, SOUTH AFRICA

Author: Rutger Wielenga

Supervisor : Associate Proffessor Simon Hull

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Master of Philosophy in Geomatics

Geomatics Division, School of Architecture, Planning and Geomatics,

Department of Engineering and the Built Environment, University of Cape Town,

South Africa

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ABSTRACT

There are natural hazards affecting communities all over the world. These events also take place in South Africa. South African disaster management legislation emphasises the indigenous knowledge of people who are most affected when hazards turn into disaster. Participatory GIS in the form of activities building and using three-dimensional models (P3DM) has been used internationally to enhance community engagement and to ensure better information exchange between people who live in the area and the disaster officials and consultants who currently inform decisions. P3DM was introduced in uMgungundlovu District Municipality through a progressive case study methodology with workshops in four locations introduced by municipal officials. This research focused on the officials' perceived value of using P3DM activities to enhance their standard disaster risk management practices.

Lightning, fires, earthquakes and strong winds are all natural hazards experienced by people living in communities. Over a period of several generations, these people have developed knowledge local to their area that is relevant in planning to reduce the risk of disasters in their area. The disaster risk management legislation governing this planning requires the sharing of local knowledge. The implementation of the legislation and the sharing of local knowledge are challenging. Participatory three-dimensional modelling (P3DM) has been used in the Global South as a novel method to promote knowledge sharing in this context. Although this method is commonly used elsewhere in the Global South, it has not yet been used or introduced in South Africa.

Through a progressive case study in four locations in uMgungundlovu District Municipality, P3DM was introduced to stakeholders in disaster planning. There was an opportunity to analyse and assess the perceived value of P3DM to stakeholders at each location. Observational case study methods including semi-structured interviews allowed data collection and analysis to assess the perceived value of P3DM. P3DM was found to add value to stakeholders already familiar with incorporating local knowledge in disaster planning. Officials and community members attending workshops where P3DM activities were introduced recognized that building models and adding LIK to the models facilitates knowledge sharing.

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PLAGIARISM DECLARATION

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS AND ABBREVIATIONS

3D	Three dimensions / three-dimensional
CBDRA	Community Based Disaster Risk Assessment
DM	District Municipality
DRR	Disaster Risk Reduction
DMA	Disaster Management Act
GIS	Geographic Information Systems
KZN	KwaZulu-Natal Province
LIK	Local and Indigenous Knowledge
LM	Local Municipality
NDMF	National Disaster Management Framework
PGIS	Participatory Geographic Information Systems
P3DM	Participatory Three-Dimensional Modelling
SK	Scientific Knowledge
UMDM	uMgungundlovu District Municipality

GLOSSARY OF TERMS

Community is an omnibus word because of the range of meanings attached to it (Hillery, 1963). In line with Maguire & Cartwright (2008), in this dissertation the similar characteristics, including customs, traditions and shared beliefs, of the group of people define the community whether living in the same location or not.

Community-Based Disaster Risk Assessment (CBDRA) occurs through the self-assessment of community vulnerability that can be conducted through community workshops.

Community resilience refers to the ability of an affected community to successfully adapt using its own resources while external processes, stresses, or major disruptions occur (Dekens, 2007; Tiernan *et al*., 2019).

Disaster occurs when a natural hazard causes widespread human, material, economic, or environmental losses and disruption that overwhelms the community that is affected (UNISDR, 2009; UNDRR, 2016).

Disaster risk reduction (DRR) has been promoted by governments and international organisations (UNISDR, 2007; UNDP, 2010; UNDRR, 2023) because there is greater acceptance that disasters are not simply 'acts of God' but are impacted by human behaviour (O'Keefe *et al*., 1976; Chmutina & von Melding, 2019). Disasters are not natural; therefore, there is a focus on human behaviour that can be changed (Kelman, 2020).

Geographic Information Systems (GIS) are geographically oriented information systems using computers to analyse, visualise, process and collect data. These tools increase the efficiency of the data handling occurring in spatial locations (Longley *et al*., 2015).

Local and Indigenous Knowledge (LIK) is considered to be ingrained in practise and experience to respond to local situations (Wang et al., 2019), a recognition that people have, over generations, developed an understanding native to their area (Chowdhooree, 2019). This understanding encompasses knowledge concerning weather patterns, vegetation, medicinal plants, and adaptation techniques when environmental hazards occur (Cuaton & Su, 2020; Bwambale et al., 2022).

Natural hazards are not synonymous with disaster. Hazards are extreme, naturally occurring, geophysical processes that occur such as earthquakes, flooding, tornados (Membele, *et al*., 2021).

Participatory Geographic Information Systems (PGIS) encourage collective exercises that includes various realities to build geographic systems that allows different spatial representations (Elwood, 2009). It has developed into a distinct component of GIS aimed at an approach to GIS that can increase the engagement of historically marginalised communities (Radil & Anderson, 2019) allowing community participation to adapt conventional GIS (Elwood, 2009).

Participatory Three-Dimensional Modelling (P3DM) allows rural communities to incorporate their knowledge into GIS and bridges gaps between knowledge types (Rambaldi & Callosa-Tarr, 2002) through use of topographic information that incorporates LIK. Creating the resulting user-friendly data storage and symbolising solid 3D models facilitates discussion of community memories (Rambaldi, 2010). P3DM allows visualisation of LIK onto land elevations based on scaled and geo-referenced relief models that are accessible to community members (Piccolella, 2013). P3DM includes stakeholder engagement between government officials and community members through collaborative mutual learning (Dovarch, 2017).

Scientific Knowledge (SK) concerns knowledge that is evidence- and peer-review based rather than anecdotal or experience-based (Hermans *et al*., 2022). SK is understood as knowledge based on formal education (Gaillard & Mercer, 2013).

The **vulnerability** of a community affects the potential for a disaster to result from a natural hazard (Cannon, 1994; Gaillard, 2010). Differences in ethnicity, economic class, age, and gender influence the potential negative impact of natural hazards (Cannon, 1994).

1. Orientation

Critical in effective planning to reduce the negative impact of natural hazards is knowledge local to an area and the sharing of knowledge between those who live in that area and external actors (Wisner, 1995; Twigg, 2004; Shaw *et al*., 2009; UNISDR, 2019; Cuaton & Su, 2020; Cadag, 2022). In a situation in which knowledge needs to be shared for disaster planning, it is difficult to encourage interaction between local communities and people who use scientific knowledge (frequently living outside the community). Although there is recognition of the value of community knowledge, conventional disaster planning is based only on scientific knowledge (Weiner *et al*., 1995; Hadlos *et al*., 2022), and local knowledge is not sufficiently valued (Brodnig & Mayer-Schonberger, 2000; Gaillard & Mercer, 2013; Cuaton & Su, 2020). This dissertation encounters the challenge of bridging the gap between types of knowledge using participatory geographic information systems (PGIS) activities known as participatory three-dimensional modelling (P3DM).

The use of P3DM to bridge the gap between knowledge types could lead to mutual learning without privileging one knowledge type over the other (Ismail-Zadeh *et al*., 2017). P3DM activities have been used internationally for disaster planning (Gaillard & Maceda, 2009; Maceda *et al*., 2009; Dwamena *et al*., 2011; Ramirez-Gomez *et al*., 2017). However, as far as can be determined from current academic publications, P3DM may not yet have been introduced in South Africa regarding the perceived value of bridging divides between knowledge types and better communicating the knowledge of local communities during disaster planning events, as required by Section 2.1.4 of the National Disaster Management Framework (COGTA, 2005). This section of the framework states that "information collected using more technically sophisticated methods employed by risk scientists can be significantly enhanced by local and indigenous knowledge relating to disaster risk management" (COGTA, 2005: 31).

There was once a romanticised notion that people who were native to an area knew that area and were "at one" with their area. It later became discredited in favour of scientific methods (Heyd *et al*., 1996; Berkes *et al*., 2000). There is now renewed interest in the knowledge held by people living in an area (Berkes *et al*., 2000; Bohensky & Maru, 2011; Wheeler & Root-Bernstein, 2020) due to the recognition that people have, over generations, developed an understanding native to their area (Chowdhooree, 2019). This understanding encompasses knowledge concerning weather patterns, vegetation, medicinal plants, and adaptation techniques when environmental hazards occur (Cuaton & Su, 2020; Bwambale *et al*., 2022). When hazards occur (Dekens, 2007; Pierro *et al*., 2022), residents

should be consulted as their perceptions and local knowledge (Reyes *et al*., 2019; Cuaton & Su, 2020) are relevant to disaster planning.

An inspiration for the project was to increase the level or ladder of community participation (Arnstein, 1969) in disaster planning by introducing P3DM to those in communities experiencing natural hazards (see Section 6.4). The focus on communities in disaster planning is backed by National Disaster Management Framework Section 1.3.2.2, which states that communities are "at the coalface of disaster management" and should drive local government response to natural hazards (COGTA, 2005: 18). Therefore, P3DM activities are more concerned about enhancing community participation and incorporating their knowledge in planning than increasing the amount of data collected or the accuracy of that collected data (Banaynal & Dwamena, 2011) as is common in PGIS research projects (Dunn, 2007).

1.1.Research Aims, Objectives and Questions

The aim of this research is: **to investigate the perceived benefit of introducing P3DM in uMgungundlovu District Municipality during community based disaster risk management workshops to improve knowledge sharing as required by South African disaster risk management legislation.**

This investigation required the introduction of P3DM activities to government officials and private consultants working in the disaster management field in South Africa. It is clear (van Riet, 2009; Reddy, 2010; van Riet & van Niekerk, 2012) that community based disaster risk mangemeng processes have limitations in following the requirements of National Disaster Management Framework relating to the community participation and integration of LIK. PGIS through P3DM activities could prove to be a novel solution for these workshops in South Africa. Through this research project, relevant disaster officials and private disaster consultants were introduced to P3DM activities so that they could decide whether to incorporate P3DM activities into their future disaster planning processes.

The aim is supported by the following objectives and research questions:

Table 1-1 Research objectives and questions

Objectives	Research Questions
A. Understand the perceived benefits of LIK sharing during disaster workshops	1. What are the perceived benefits of sharing LIK about disasters among stakeholders? 2. In international agreements, what are the perceived benefits of sharing LIK about disasters? 3. In South African disaster legislation, what are the perceived benefits of sharing LIK about disasters?
B. Understand the current limitations of LIK sharing during disaster workshops	4. What are the challenges in sharing LIK internationally about disasters? 5. In the current South African community workshops, what challenges are faced in sharing LIK about disasters?
C. Assess the perceived benefit of P3DM for community workshops	6. Internationally, how does P3DM enhance LIK sharing in community workshops? 7. During community workshops in South Africa, what is the perceived benefit of P3DM for sharing LIK about disasters?

1.2.Ethical Considerations

In accordance with the research ethics requirements of the University of Cape Town (UCT), a letter requesting permission to conduct research and to include photos and videos was presented to and signed by the P3DM workshop participants. The participants were informed in advance that participation was voluntary and that anyone could leave the research without needing to provide a reason (see Annexure A). Ethics permission was granted with the requirement of gatekeeper permission before field work could start. Section 4.3 describes this required process before field work was initiated. The collected data were stored according to the Data Management Plan agreed with UCT. In terms of this plan, no personal details of any respondents were included in any analysis or disclosed to anyone outside the research project.

1.3.Assumptions, Limitations, and Challenges

There are two assumptions that are important to this research project. First, people have knowledge relevant to the locale where they live. They and their family, who have lived in the area for more than one generation, know of natural hazards. The second is that those people in the place where the hazards occured have a desire to share this knowledge with each other and people who are not from

their place to plan for reducing the risk of the hazards becoming disasters. Using these assumptions and based on research articles detailing decades of international research experience (see Section 2.1) in the use of LIK, it is relevant to test whether these assumptions match the reality on the ground in South Africa.

A limitation of this dissertation is that it focuses on applying internationally proven P3DM activities in a particular South African district municipality. Certain characteristics of the current disaster risk management process in South Africa may not be well suited for the use of P3DM (see Section 6.2). This project is limited to assessing the perceptions of disaster workshop participants, especially government officials, regarding the value of P3DM activities at this location in South Africa.

The project was challenging due to a lack of knowledge of the field of study and unfamiliarity with disaster risk management government officials at the district and local municipal levels. These officials were important in facilitating P3DM events where the desired activities were introduced. Developing appropriate field work methods with a prior lack of awareness and no easy access to information about the standard community workshop processes was challenging. Similarly, it was challenging to work with officials were under-resourced and limited in the time they had available to be involved in a research project (see Section 6.5).

1.4.Scope of the Research

The research scope is not about comparing different PGIS methods. This ressearch examines the perceived benefit of P3DM to community disaster workshops. This focus will define the foundation of the investigation of the capabilities and limitations of P3DM use. Disaster legislation and international and local experiences relevant to LIK sharing in disaster workshops will be included in this examination. Observational processes during the workshops and interviews before and after were employed to analyse the perceived benefits of introducing P3DM in uMgungundlovu District Municipality (UMDM).

This study does not consider alternative participatory GIS methods. An assessment of whether P3DM would be preferable to the alternative participatory GIS methods is outside the scope of this project. Rather, the project considers only the perceived benefits of P3DM to disaster workshops. A comparison of varied participatory GIS methods would be interesting for future research (see Section 7.2). Additionally, this research does not consider the broader challenges of disaster risk

management in South Africa. Institutional, socio-political, and resource-related constraints in this field are outside the scope of the study.

1.5.Bias

A research paradigm underpins the type of theory and approaches used in a research project. For the research described in this dissertation, a post-positivist paradigm is employed. Positivism (and post-positivist) aims to achieve objective research with a focus on scientific rigour, following detailed processes to ensure that the research could be replicated in the manner of experiments (Steenhuis, 2015). While positivism asserts that there is truth that can be known, post-positivism operates with the understanding that bias influences our methods and analyses (Ryan, 2006). Thus, truth exists, but it may never be fully known due to flawed human ability. Any claims about reality should be critically examined (Guba & Lincoln, 1994). This is relevant to this project as introducing P3DM into workshops can impact the behaviour of participants. The environment where workshops occur cannot be controlled. A focus on government officials and their perceptions of the value of P3DM activities while they are driving the workshops where P3DM activities are introduced creates opportunities for bias. This bias and its impact will never be clear or defined.

Knowing that there are uncontrollable elements in which undefined bias is involved informs a focus on triangulation of data collection and thorough processes of data analysis. A post-positivist approach to research methodologies emphasises falsifiability, data triangulation, collecting situational information, and data that indicates the motivation that people give for their behaviour (Guba & Lincoln, 1994). The methodologies available include grounded theory, case studies, action research, feminist standpoint research, survey research, and experimental research (Crotty, 1998). The progressive case study method (see Section 3.1) is the approach used in this project, where elements of the case study and grounded theory approach are combined.

1.6.Outline

This dissertation contains seven chapters. The chapters are organised to present a report containing the questions driving the research, methodology development, data collection, analysis of data, discussion and conclusion. The following table details which sections of each chapter address which objectives and research questions.

Table 1-2 - Dissertation outline

Objective	Research Question	Chapter	Section
Objective A	Question 1	Chapter 2	2.2.1
	Question 2	Chapter 2	2.3
	Question 3	Chapter 2	2.3
Question B	Question 4	Chapter 2	2.2.2
	Question 5	Chapters 2 and 4	2.3.2 and 4.2
Question C	Question 6	Chapter 2	2.5.2
	Question 7	Chapter 5	5.2

Chapter 1 provides an introduction and orientation to the research project. This chapter introduces diverse types of knowledge, disaster risk reduction planning, South African legislation, current limitations in legislated community participation, and a proposed solution for involving P3DM activities. The research aims, objectives, and questions were also outlined in this chapter.

Chapter 2 provides a review of academic literature relevant to this study. Certain research objectives and questions required a review of the literature that were answered in this chapter. The theoretical foundation of the research project is the focus of this chapter.

Chapter 3 provides the suitable methodology. The method and design of the research are presented. Before deciding on the manner of research, the background and assumptions underpinning the methods should be examined.

Chapter 4 provides a case study in a narrative account of the case study. The field work component across the four locations in a single case study is described. At these locations, a practical exercise involving multiple workshops was conducted to answer the research objectives and questions.

Chapter 5 provides the analysis and results, starting with the analytical strategies used in this study. Multiple methods of analysis are illustrated. The analysis was an iterative process that was initiated while the data were collected using a progressive case study approach. The results of the analysis are presented at the end of this chapter.

Chapter 6 provides a discussion of the topics resulting from the analysis of the results. This study considers whether using P3DM activities is appropriate for standard community disaster workshop

processes, where the activities could best be used in disaster planning, the effect of the activities on data quality, and the potential future implementation of P3DM in disaster planning in South Africa.

Chapter 7 presents the final conclusions and recommendations concerned with the overall aims and objectives of the project. The findings of this research are summarised. The recommendations and future work are also considered.

2. Literature Review

This chapter provides a summary of the academic literature concerned with diverse topics underpinning the research, including types of knowledge, DRR, PGIS, and the international use of P3DM activities enhancing community disaster workshops. Of the research questions derived from the objectives, questions 1, 2, 4, and 6 require a review of the current literature. These research questions are concerned with the perceived benefits of sharing knowledge, the benefits of the sharing of knowledge in international agreements, the challenges experienced internationally, and P3DM enhancement in community workshop experiences. An overview providing insights within current research linked to these topics is included here to provide a foundation of existing knowledge and indicate gaps that motivate further research.

2.1.Knowledge Types

Different types of practise have gained recognition when desiring to increase participation in planning processes (Sillitoe, 1998; Nadasdy, 1999; McLennan, 2018). The knowledge of the community, together with the knowledge developed through structured learning, should be used in collaborative decision making by appreciating multiple knowledge types (Sillitoe, 2018). In South Africa, the national disaster management framework (NDMF) requires the participation of numerous stakeholders where experiences and practises are shaped by the location where hazardous events occur (COGTA, 2005). The desire for inclusive citizen involvement in the delivery of services (Mchunu & Theron, 2014) at the municipal level assumes that citizens in their communities have the knowledge they desire to share. Disaster planning by default is still dominated by SK knowledge based on formal education without sufficient appreciation for LIK and leaving a need to bridge the knowledge types (Balay-As *et al*., 2018).

2.1.1. Local and Indigenous Knowledge (LIK)

Those active in working with knowledge particular to a community living in an area use differing terminology to describe this knowledge because there is not a standard definition (Kelman *et al*., 2012). The diversity in terms indicates that the definition is still disputed (Cuaton & Su, 2020; Hadlos *et al*., 2020). There appears to be a preference to use 'local knowledge' based on the perception that geographic location is the most important factor determining the knowledge (Antweiler, 1998; Dekens, 2007; McWilliam *et al*., 2020; Trogrlic *et al*., 2021) compared with a preference for the term 'indigenous knowledge' (Shaw *et al*., 2009; Magni, 2017; Dube & Munsaka, 2018; Lambert & Scott,

2019; Membele *et al*., 2021) denoting the significance of culture and community regardless of location (Huntington, 2000). Pierro *et al*. (2022) combined local, traditional, and indigenous knowledge into one definition and thereafter referred to this as 'local knowledge'. Cuaton and Su (2020) combined the two and refer to 'local-indigenous' knowledge in describing their research regarding disaster risk reduction in the Philippines. In South Africa, the NDMF in Section 2.1.4 speaks of "local and indigenous knowledge" (COGTA, 2005: 31). Based on this discussion and in line with the legislation and research in this field where a desire exists to include indigenous knowledge in planning, the term local and indigenous knowledge (LIK) will be used in this dissertation.

Members of communities, who manage more than half of the global land (WRI, 2021), understand the value of the land that they manage effectively (Oliver-Smith, 2016; WRI, 2022). They develop knowledge about their location (Lambert & Scott, 2019; Franco-Moraes *et al.*, 2021; Bwambale *et al.,* 2022), including about medicinal and food resources available in their place (Camara-Leret *et al*., 2019), and practise in response to hazardous situations experienced (Bwambale *et al.,* 2022). Therefore, LIK includes cultural customs, vegetation, land use, agriculture, medicine, and responses to natural hazards and the impact of climate change (Oliver-Smith, 2016; Lambert & Scott, 2019; Bwambale *et al.,* 2022; Sultana & Luetz, 2022). Therefore, there is a clear value in the use of LIK, leading to the inclusion of community members and their knowledge.

Who are the members of a community that access LIK? Hillery (1963) refers to community as an omnibus word because of its range of meanings. Two aspects are commonly described: one focuses on place and the other is relational; sometimes these aspects are combined (McMillan and Chavis, 1986; Norris *et al.*, 2008). The community should not only be viewed as a research subject providing content for the projects of those residing outside the community (Levinson, 2017; van Niekerk *et al.*, 2017). In line with Maguire & Cartwright (2008), in this dissertation, the similar characteristics of the group of people define the community, whether living in the same location or not.

Community resilience refers to the ability of an affected community to successfully adapt using its own resources while external processes, stresses, or major disruptions occur (UNISDR, 2002; Dekens, 2007; Tiernan *et al*., 2019). Communities benefitting from their social capital (Section 2.2.1) have proven to be more resilient — being able to cope, and adapt, and thrive — than anticipated by the international disaster community (Pelling, 2011, Membele *et al*., 2021). This resilience of communities has been a driver of interest in the use of LIK (Hadlos *et al*., 2022). As the environmental

hazards are not always preventable, the priority for governments is to increase group and community resilience (Maguire & Hagan, 2007).

Planning for the reduction of the impact of hazards should lead to an interest in the communities affected by the hazards (Gaillard & Gomez, 2015). Integrating LIK held within the community with SK effectively leads to a desire for co-production methods to reduce the risk of disaster and respond to changing climate (Bremer & Meisch, 2017; McLennan, 2018). Recent literature lists the advantages of knowledge co-production. The list includes improving trust between stakeholders that enhances the likelihood of public acceptance of policies. Co-production of knowledge can shift power relations as participants understand the value of different worldviews. Diverse participation in the co-production of knowledge about a location can improve decision making (Zurba *et al*., 2022). Co-production discussions (going back to Arnstein's ladder of participation (1969) concern whether LIK is considered only as a 'nice to have' extra value or whether it is critical to good governance and planning (Whyte, 2017; Latulippe & Klenk, 2020).

2.1.2. LIK Differences from SK

LIK is considered to be ingrained in practise and experience to respond to local situations in contrast to rigorous generalisable scientific knowledge (SK) that is relevant in objective terms for international application (Wang *et al*., 2019). LIK is contrasted with SK, whether it has its origins in Europe, China, or the Arab world (McWilliam *et al*., 2020). A standard understanding of modern SK concerns knowledge that is evidence- and peer-review based rather than anecdotal or experience-based (Hermans *et al*., 2022). SK is understood as a knowledge type based on formal education (Gaillard & Mercer, 2013). In practise however, there is not always a clear distinction between LIK and SK (Argawal, 1995), and knowledge types do not need to be mutually exclusive (van Niekerk *et al*., 2017). SK is still conventionally used to understand and respond to naturally occurring hazards (Gaillard & Maceda, 2009; Trogrlic *et al.*, 2022). Bridging knowledge types would enhance planning for the occurrence of natural hazards.

The second reason for a challenge in incorporating LIK in research or use for planning purposes is resistance to using alternative perspectives and knowledge types because of the inflexibility of methods and resistance to change (Huntington, 2000) or denial that a difference exists between knowledge types. Agrawal (2014) reminds us that the recent focus on a dichotomy between knowledge types matches an earlier focus on 'primitive' cultures that were perceived to be more

connected to their environment and less analytic, and that hence, this knowledge was less dependable. Shaw *et al*. (2009) emphasised lifestyle rather than identifiable methods as being inherent to LIK. This lifestyle learned over generations includes practises that are best used in times of disaster. A distinction between a knowledge type as a particular method or tool to use and a knowledge type as a lifestyle may create the opportunity to examine the benefits of experiences that people have in their area based on a lifestyle relevant to their location. LIK is recognised as greater than mere knowledge because community members can experience knowledge as part of their holistic experience of their environment (Sultana & Luetz, 2022). LIK as a holistic experience has been used in diverse ways and can be shown to be valuable in collaborative knowledge production.

2.1.3. LIK Reliability

The fact that SK learned through formal education that is peer-reviewed is considered to have primacy over LIK can be traced back to colonial times. During European exploration journeys to other nations around the world, the people they encountered were assessed in terms of their ability to learn and incorporate SK. SK-derived technologies legitimated colonial procedures (Smith, 2021). This background still influences the desire to evaluate LIK through comparison with SK. Those familiar with SK question the reliability of LIK (Yeh, 2016). Even researchers familiar with the value of LIK question whether increasing changes in climate would limit community adaptation using LIK (Bwambale *et al*., 2022). Although there has been much research into the value of LIK, its inclusion in development initiatives, climate change discussions, or planning to reduce the risk of disaster remains challenging. A major reason for this is the questions of reliability and trust that the dominant knowledge users have about LIK (Sillitoe, 2010).

Brook and McLachlan (2005) and Yeh (2016) question whether LIK should be limited to being assessed in terms of SK. Concerns about the reliability of LIK negatively impact the use of this knowledge. Whether the use of LIK is sufficient for data collection purposes or should always be used to build resilience and increase participation in planning is of concern and leads to discussions between certain researchers (Gilchrist & Mallory, 2005; Brook & McLachlan, 2005; Gilchrist & Mallory, 2007). Rather, LIK should be used on its own merits. Where LIK is used, those using it should still be concerned about errors, just as there can be errors in data produced based on SK (Huntington, 2000).

2.1.4. LIK from integration to knowledge leadership and co-production

When understanding the value of LIK, after considering whether LIK is dependable and what distinguishes it from SK, the practical use of LIK must be considered. A range of knowledge types should be used – and methods to bridge the knowledge types should be investigated - to ensure effective responses to the complex challenges of a changing climate (Whyte, 2017; Norström et al., 2020; Wheeler & Root-Bernstein, 2020; Zurba et al., 2022), considering land use and DRR affecting members of the community.

Sharing knowledge types can lead to bridging divides between SK and LIK. This stated ideal in South African legislation is not always properly realised. The history of knowledge sharing shows a move from extracting knowledge from communities through a desire to share knowledge types to the recent increase in literature showing a striving for knowledge co-production (Bremer & Meisch, 2017; Chapman & Schott, 2020). Co-production between government and communities through bridging knowledge systems to ensure good service delivery ensures that community members are not limited to passive receivers of services (Bremer & Meisch, 2017). Sharing knowledge and expertise that people have that is unique to their society (Magni, 2017) with external actors has recently become of greater interest to researchers (Agrawal, 1995; Tibby et al., 2007; Bohensky & Maru, 2011; Zurba et al., 2022).

This focus on the local knowledge of a community is a move away from the centrality of scientific knowledge (Agrawal, 1995; Haque, 2019; Chapman & Schott, 2020). Knowledge local to a location has become better recognised, and there is greater interest in combining this knowledge with SK (Chapman & Schott, 2020; Zurba et al., 2022). Ideally, the co-production aims to enhance LIK during research or planning, including capacity building and embedding methods that are relevant to the culture, including storytelling (Schott et al., 2020).

2.2.Benefits and Challenges of Sharing Knowledge

Research question 1 deals with the perceived benefits of sharing knowledge about disasters to create bridges between knowledge types. Research question 4 addresses the challenges of sharing knowledge about disasters as described in the international literature. This section considers these two research questions.

2.2.1. Benefits

When considering question 1, the perceived benefits of sharing knowledge about disasters among stakeholders are relevant. The use of LIK can enhance community resilience to change (Chowdhoree, 2019; Fernandez-Llamazares *et al*., 2021) and responses to events that they experience (Haque, 2019). LIK shared within the community builds networks of support and communities of practise that enable the community to cope better when the stress of a changing climate affects them. Customs using LIK include extended families that shield individuals from hazardous experiences (Dube and Sekhwela, 2007). Customs and unwritten practises persist and are multifaceted (Haque, 2019). Members of communities can consider connections with their location that are managed through communal rituals that develop reciprocal relationships with their environment (Quilo *et al*., 2015). LIK can provide unquantifiable resources to the communities based on their collective experiences developed into behaviours available to them (Dube & Sekhwela, 2007).

Behaviours and communal rituals that lead to action supporting community action are part of social capital (Dynes, 2005). An aspect of social capital is the relationships between community members (Aldrich, 2017), which enhance collaboration between neighbours (Roque *et al*., 2020). Social organisations, such as clubs or religious institutions, can bridge divides within a community (Aldrich, 217) to obtain donations and provide accommodation during a disaster (Roque *et al*., 2020). Other institutions provide links outside the community (Aldrich, 2017; Roque *et al*., 2020). The sharing of knowledge and experiences occurs within these institutions. Due to social capital, community members have organising potential in response to disasters as there are various response methods available (Dynes, 2005; Chamlee-Wright & Storr, 2011; Wood *et al*., 2013). Those without access to social capital find recovery and response to natural hazards especially difficult, making them vulnerable to disasters (Blake *et al*., 2017). However, there are limitations in focussing on resilience as it can lead to false hope of future change. The resilience of communities must not remove the responsibility of governments to respond to crises that can overwhelm the community (Diprose, 2015).

The concept of resilience, along with vulnerability, has become more prevalent in Western academic research. There is an increased emphasis on individual responsibility and the potential of a society to respond to disasters. Consequently, people are deemed to have responsibility for their own vulnerability rather than governments or international organisations (Bankoff, 2018). Vulnerability is a measure of the likelihood of suffering a negative impact due to a negative event, whether that

event is natural, economic, or political. The vulnerability of a community affects the potential for a disaster to result from a natural hazard (Cannon, 1994; Gaillard, 2010). Differences in ethnicity, economic class, age, and gender influence the potential negative impact of natural hazards (Cannon, 1994). Members of communities must cope with the impact of hazards due to both local and international processes; their vulnerability may change over time (Bankoff, 2004). Decisions and behaviours of people create situations where hazards overwhelm them, leading to disaster (Kelman *et al*., 2016). Coping in the community can be improved through support using LIK (Few, 2003).

Those relying on SK historically tend to ignore the value of LIK (Rojas Blanco, 2006; Gaillard & Mercer, 2013). Programmes benefitted communities rely on SK; however, they are not always acceptable to communities (Vasileiou *et al*., 2022). This motivates the desire for more examples of LIK use and experiences (Rojas Blanco, 2006; Vasileiou *et al*., 2022). There is also a desire to reduce the chance of losing valuable LIK (Rojas Blanco, 2006; Fernandez-Llamazares *et al.,* 2021). In existing academic literature, aspects related to the value of LIK include describing, explaining, and understanding the environment in which community members live (Rojas Blanco, 2006). On the basis of this understanding, solutions to the challenges of natural hazards intensified by climatic changes can be developed. Finding alternative responses to natural hazards (Huntington, 2000) and to standard scientific views is advisable (Bohensky & Maru, 2011).

Community members notice changes in their environment and adapt where possible as LIK provides solutions (Huntington, 2000; Rojas Blanco, 2006) required for their adaptation (Oliver-Smith, 2016). These adaptation methods were in place for community members before SK and technologies were introduced to them (Chowdhoree, 2019). Therefore, taking this knowledge into account should be a standard practise when planning for future events such as natural hazards. Interest in LIK related to response to these hazards increased after the Christmas 2004 Indian Ocean tsunami, where communities differed in their responses to the event (McAdoo *et al*., 2006; Gaillard *et al.*, 2008; Syafwina, 2014). Similar observations have been made regarding other events at other locations (Cuaton & Su, 2020). LIK use in communities produces viable solutions to the challenges of their development that should inform policy making at national and international levels (Rojas Blanco, 2006). International organisations such as the World Bank (Gorjestani, 2001) and the European Union (Shaw, 2009) have demonstrated an understanding of the value of LIK.

When alternative views are encouraged in developing scientific opinions, LIK should be considered (Huntington, 2000; Kimmerer, 2002; Vasileiou *et al*., 2022). LIK is not divided into different

components as SK because community members have a holistic view of the location where they live (Turner *et al*., 2022; Haque, 2019). Where the sustainable development of communities is concerned, the value of LIK should be recognised (Chowdhoree, 2019; Turner *et al*. 2022). Community members are aware of the natural processes that occur during seasons in particular locations where LIK is developed over extensive periods of time (Turner *et al*., 2022). Due to this connection with their location, LIK provides what is required to survive and thrive in their location (Magni, 2017; Chowdhoree, 2019; Turner *et al*., 2022). Community members have developed practises relevant to their location using sustainable methods (Magni, 2017). The practises are not transferred generationally through schoolroom exercises; rather, LIK is exchanged through storytelling, ceremonies, and participatory exercises (Turner *et al*., 2022).

2.2.2. Challenges

The challenges of sharing knowledge are a concern of research question 4. There are diverse components to this question. Being aware of the differing power relations in a community is important when working with LIK. There are knowledge gatekeepers in disaster planning. LIK should not necessarily be accepted without rigorous examination. Recognising that there are community experts in different fields is relevant. Community apathy also adds to these acknowledged challenges when conducting research seeking to incorporate LIK.

Differences in power relations between those who use SK and LIK can make it difficult for LIK users to express their knowledge (Wheeler & Root-Bernstein, 2020). Effectively sharing knowledge requires efforts to incorporate knowledge holders in the complete process of research or planning. Maintaining equal and meaningful relationships and ensuring appropriate roles for these LIK holders is a challenge (Schott *et al.,* 2020; Wheeler & Root-Bernstein, 2020). Whether they are participants, stakeholders, or drivers of their own development can impact the sharing of LIK. The use of LIK and potential abuse creates challenges in potentially damaged relationships. This particularly occurs when community members lose ownership of their LIK.

Drivers of SK are often gatekeepers of knowledge, potentially limiting the potential for LIK to enhance disaster planning (Wheeler & Root-Bernstein, 2020). It can be challenging to document LIK (Huntington, 2000; Davis & Wagner, 2003). When documenting and testing the reliability of LIK, the method should be as rigorous as that when using SK. There can be value in identifying the community members who have expertise in the relevant question being researched (Davis & Wagner, 2003) as

not all community members have expertise on all matters. The concern about maintaining community interest was greater than any concerns regarding sharing data. Researchers using PGIS methods commonly express concerns about maintaining the interest of participants in PGIS activities (Brown & Kytta,2018).

There is a danger that communities become apathetic (Hilliard & Kemp, 1999) due to long experience in being recipients of aid without being involved in their own development. The state can become too dominant in providing services without the input of the people in their communities. If the only way in which communities can express themselves is through community protests (GGLN, 2013), the potential of using LIK and sharing knowledge is missed. Violent community responses can undermine the basis of citizenship (van Holdt *et al.*, 2011).

2.3.Knowledge about Disasters

Natural hazards are not synonymous with disasters. Hazards are extreme naturally occurring geophysical processes that occur around the world (Membele, *et al*., 2021). These processes — such as earthquakes, tsunamis, lightning strikes, and flooding — may be rapid (Kelman, 2019) and cannot always be prevented, whereas a disaster can (Chmutina *et al*., 2019). A hazard is a serious disruption of the functioning of a community or a society, such as loss of life, social and economic disorder, and damage to the environment (UNISDR, 2009).

When a natural hazard causes widespread human, material, economic, or environmental losses and disruption that overwhelms the affected community, it becomes a disaster (UNISDR, 2009; UNDRR, 2016). A disaster is not a naturally occurring event (O'Keefe *et al*., 1976; Cannon, 1994; Chmutina *et al*., 2019). A disaster is a crisis, collectively experienced, of a long or brief period caused by the impact of naturally occurring hazards (Olorunfemi & Adebimpe, 2008). Disasters occur more often (Hadlos *et al*., 2022; UNDRR, 2022), and most fatalities occur in the Asia-Pacific region and the African continent (Vasileiou *et al*., 2022). As a result, there is an interest in reducing the risk of these naturally occurring hazards developing into disasters in the future.

Disaster risk reduction (DRR) has been promoted by governments and international organisations (UNISDR, 2007; UNDP, 2010; UNDRR, 2023) because there is greater acceptance that disasters are not simply 'acts of God' but are impacted by human behaviour (O'Keefe *et al*., 1976; Chmutina *et al*., 2019). Disasters are not natural; therefore, there is a focus on human behaviour that can be changed

(Kelman, 2020). With better preparation, the disaster impact is reduced (UNISDR, 2009). There is an understanding that people can mitigate the impact of disasters (van Riet, 2009). This means that people are not helpless victims of disasters (Pantti, 2019) and should be part of the planning process for DRR (Gaillard, 2010; van Niekerk *et al*., 2017). With a better understanding of these terms, the risk of a negative impact of disasters can be understood as a blend of disaster and the vulnerability of people (UNDRR, 2022).

Any understanding of planning for DRR is inherently a collaborative process that should include all knowledge types and stakeholders (Gaillard & Cadag, 2013). This process should be a focus before a natural hazard ever occurs rather than providing attention to a disaster after it has impacted a community (Kelman, 2019). Those first impacted by a disaster are normally members of a community (COGTA, 2015; Gaillard, 2010); thus, planning to reduce the risk of disaster should focus on their coping mechanisms. Mitigation of disasters through self-assessment of community vulnerability assists communities in improving their problem-solving abilities, leading to increased resilience (Norris *et al*., 2008).

Self-assessment of community vulnerability can be conducted through community-based disaster risk assessment (CBDRA). Two main methods to achieve effective CBDRA involve either a focus on locally relevant messaging and awareness creation or locally led initiatives, engagements, and workshops (Ryan *et al*., 2020). The latter is part of South African and internationally recommended processes (COGTA, 2005; Texier-Teixeira *et al*., 2014; van Niekerk *et al*., 2017; UNDRR, 2022). When the community is at the centre of the CBDRA process, it can own the DRR process independent of outside expertise (van Niekerk *et al*., 2017). The international best practise recognises the typical dichotomy between LIK and SK during CBDRA and desires improvement in the inclusivity of communities and their LIK (UNDRR, 2022). CBDRA should hence achieve increased community resilience, reduce suffering and be participatory (Lassa *et al*., 2018; Ryan *et al*., 2020; Sarabia *et al*., 2020).

Hazards occurring in diverse locations around the world generate the greatest mortality in developing countries (Field, 2012) without affecting all people equally (Cannon, 1994; Gaillard, 2010). These naturally occurring processes (Cannon, 1994; Kelman *et al*., 2016) become disasters not due to the scale of the event but the ability of the affected community to absorb the impact of the event (Lechat, 1990; Cannon, 1994; Chmutina *et al.,* 2023). Exposure to the risk of a disaster can differ in part based on various socioeconomic factors. Efforts to reduce risk should focus on preventing

hazards from becoming a disaster (Kelman *et al*., 2016) for all stakeholders affected by the hazard. This means that there is a responsibility to resist the creation of risk in the future through better decision-making (Wisner & Lavell, 2017). As disasters are occurring more frequently internationally (Sauerborn & Ebi, 2012; UNISDR, 2023) and have a greater impact on people who are poor (Khandlhela & May, 2006) and those who live in developing countries (Lechat, 1990; Alcantara-Ayala, 2002), such as South Africa, the need for better decision-making that is inclusive of all stakeholders is clear and legislated (COGTA, 2015). Legislation is not developed in a vacuum. South African disaster risk management legislation, the National Disaster Management Act (57 of 2002) (as amended) (DMA), and NDMF, including LIK, should be considered in light of international agreements focussed on DRR.

2.3.1. Perceived benefits of LIK sharing about disasters in international agreements

Question 2 considers the perceived benefits of, as stated in international agreements, sharing knowledge about disasters. International agreements followed from the Decade of Natural Disaster Reduction, which began in 1990 (Lechat, 1990; Steiner & Twigg, 2001). This focus on DRR was a response to severe events and recognition of the socio-economic conditions contributing to the vulnerability of communities. The United Nations made taking action to improve resilience an objective for members of the international community. Community-based approaches to reduce vulnerability and include LIK can be emphasised through international agreements (Steiner & Twigg, 2001). The Sustainable Development Goals, Sendai Framework 2015-2030, and Paris Agreement can interact and be linked to guide governments in DRR (Kelman, 2017; Handmer, 2019).

The Sendai Framework focuses on the role of multiple stakeholders and their engagement in planning (UNDRR, 2019; van Niekerk *et al.*, 2020; Nicodemus & Dennis, 2021). The impact of disasters on the development of people in communities is recognised in this framework. There can still be an overemphasis on technological measures rather than LIK (Tozier de la Poterie & Baudoin, 2015). Within international agreements, the value of LIK can be clearly stated (Hadlos *et al*., 2022; Lambert & Scott, 2019). The framework focuses on the contribution and complementing possibilities of LIK to established SK rather than LIK as expertise relevant to their local context (Tozier de la Poterie & Baudoin, 2015). In international agreements, the value of sharing knowledge is recognised. The level of value varies over time and across agreements. Each agreement develops best practises that guide legislation across member nations (Hadlos *et al*., 2022; Lambert & Scott, 2019).

2.3.2. Perceived benefits of LIK sharing in South African disaster legislation

Question 3 concerns South African disaster legislation and the perceived benefits of sharing local knowledge about natural hazards in the DMA and NDMF. The DMA mandates all South African local municipalities to conduct DRR planning with multiple stakeholders, including communities, using LIK (COGTA, 2015). This focus on considering local communities affected by a hazard conforms to international best practises based on the Sendai Framework for Disaster Risk Reduction (UNISDR, 2015). The DMA provides guidelines for planning that address disaster reduction (COGTA, 2015). The legislation requires a decentralised process of planning for disasters and an emphasis on community involvement in the planning (van Niekerk, 2014). When planning for DRR (COGTA, 2015; van Riet & van Niekerk, 2012), the DMA, in line with this established international best practise (Holloway *et al*., 2008; van Riet & van Niekerk, 2012), recognises that responsible governance requires prioritising local understanding to ensure better disaster planning. The forward-thinking nature of the DMA has influenced various other developing countries in their DRR development (van Niekerk, 2014).

The NDMF requires that planning should occur through two complementary methods, one scientific and one CBDRA. CBDRA should be conducted under the auspices of municipal officials. This should occur through regular community engagement events (COGTA, 2005). However, due to a lack of resources and limited effective methods, this CBDRA is often outsourced to private consultants (Wentink & van Niekerk, 2017). Different stakeholders in disaster risk planning would, in optimal conditions, collaborate in the planning process (COGTA, 2005). However, this is often not occurring in practise. Meanwhile, an increase in the number of disasters experienced (WMO, 2021; IFRC, 2020) emphasises the importance of disaster planning to reduce risk that incorporates stakeholder engagement (COGTA, 2015).

Understanding of the South African disaster context increased during the project. The understanding was based on conversations with various officials at (as described in Section 4.2). As the practise developed from the DMA at the local governmental level was understood, the value of using existing disaster municipal structures when desiring to introduce workshop activities was confirmed (see Section 6.2). When a hazard event occurs, members of the community reach out to their local government officials for support. The responsibility of local municipal officials to be responsive to community members is great (Koma, 2010). This leads to challenges in responding effectively to the needs of communities.

This is all in terms of the DMA, which created disaster risk committees and forums and enrolled volunteers in disaster risk at all levels of government to reduce the risk of disaster. The DMA in South Africa created and specified disaster management organisational structures at several levels of government (see figure 2-1) (COGTA, 2015). Engagement sessions are organised regularly and normally include information sessions about fire hazards, resilience training, workshops about responses to hazards and CBDRA processes. The DMA requires mobilising community members through municipal processes to plan to reduce the risk of disaster.

Figure 2-1 South African government institutional capacity for disaster risk (COGTA, 2002)

There are current challenges in realising the DMA and NDMF requirements to share local knowledge about disasters in community workshops. This is the focus of Question 5. A challenge is that legislated DRR structures are not in place in all municipalities (Wentink & van Niekerk, 2017). This is one of the challenges faced in implementing disaster risk management legislation. There is not always optimal multiple stakeholder engagement in disaster planning processes (Reddy, 2010; Mtshengu, 2017). As a result, CBDRA in South Africa tends to operate in piecemeal moments of time when

different stakeholders are available. CBDRA, as described in the NDMF, requires awareness training, is impacted by a lack of detailed historical disaster data, and is not normally a holistic process (Reddy, 2010). There is a need for a mechanism or activity to convert the principles of CBDRA, as required by the NDMF, into locally driven practises (Wentink & van Niekerk, 2017) that can be implemented by local municipal officials rather than outsourcing to consultants (as required by the NDMF) and losing local involvement in the planning process (Reddy, 2010). Section 4.2 further explores this question in the context of the case study fieldwork.

2.4.Knowledge of Geography

Participatory GIS (PGIS) has developed into a distinct component of GIS aimed at increasing the engagement of historically marginalised communities (Radil & Anderson, 2019). A response to concerns that the GIS as initially developed was too scientific and deterministic. In the early years of the 21st century, spatial information use in decision making and ethics came to the fore. The current focus is on citizen science and further democratisation of cartography, crowdsourcing of spatial information and collaborative decision-making (Pánek, 2016; Nelson *et al*., 2022). This collaborative decision-making aims to achieve empowerment and power sharing for community members in the planning of their area (Choguill, 1996; Nethengwe, 2007).

Since the early use of GIS, there have been concerns about the emphasis on technology use and the positivistic nature of GIS without sufficient concern for the impact on the society where the information originates (Chrisman, 1987; Openshaw, 1997; Schuurman, 2000). Some experts have expressed concerns related to GIS empowering the already powerful rather than increasing access and facilitating more equitable decision-making (Openshaw, 1997). Those who desire to increase the participation of non-experts have developed tools and activities to enhance this participatory process (Voinov *et al*., 2018). Decision-making through participative mapping has been implemented around the globe since the late 1970s and 1980s (McCall, 2021).

There are many opportunities for unethical behaviour using GIS technology to benefit one group over another (Longley *et al*., 2015). This ethical debate, still ongoing today (Longley *et al*., 2015; King, 2002; Fox *et al*., 2006), is concerned with using GIS for work with LIK (Weiner *et al*., 1995). PGIS practitioners do not want to increase divisions within communities (King, 2002). PGIS was developed to increase the transparency of decisions made by governments in using GIS and improve access to

the marginalised in society to those external actors making decisions in their area (Sieber, 2006). Improving the ethical use of GIS was a motivator for developing participatory GIS.

High-level participation of local actors in the disaster planning process is difficult to attain (Wisner, 1995). There can be differences between cultures in their understanding and approach to dealing with uncertainty. For example, a culture that avoids uncertainty can be prone to take fewer risks (De Man, 2003). PGIS practitioners have shown an awareness of the importance of local context and how place affects how information is exchanged (Sieber, 2006). Contributions to a planning exercise occur within a particular community context (De Man, 2003; Weyer *et al*., 2019). The PGIS activity should be a community-based project that focuses on the community where the exercise is occurring, where community members take ownership of the activity (Chapin, 2006). Access to and control of research results continue to be of concern to PGIS practitioners (Cho & Mutanga, 2021; Membele *et al*., 2021).

PGIS aims to improve the ability of non-expert stakeholders to add their knowledge to the planning process (Brown & Kytta, 2018; Brandt *et al*., 2020). Various tools and activities to create models of a location have been developed with the aim of enhancing participation (Sieber, 2006; Voinov *et al*., 2018). PGIS activities have been identified to engage marginalised communities more effectively in planning activities than other methods (Zolkafli *et al*., 2017; Ramirez-Gomez *et al*., 2017). PGIS has been defined in varied ways (Dunn, 2007). For the purposes of this research, PGIS is defined as a category of activities that bridge the gaps between local and external actors in terms of their knowledge types using spatially oriented tools, methods, and activities.

Implementing an ideal collaborative PGIS process that includes varied knowledge types and stakeholders is challenging (Gaillard & Cadag, 2013). Participatory three-dimensional modelling (P3DM), which uses topographic information-focussed community mapping to incorporate LIK, is a response to this challenge. Creating the resulting user-friendly data storage and symbolising solid 3D models facilitates discussion of community memories (Rambaldi, 2010). P3DM allows visualisation of LIK onto land elevations based on scaled and geo-referenced relief models that are accessible to community members (Piccolella, 2013). P3DM includes stakeholder engagement between government officials and community members through collaborative mutual learning (Dovarch, 2017).

There is great value in three-dimensional representations of an area because the models provide useful contextual value (Longley *et al*., 2015). P3DM is a collaborative activity that creates a three-

dimensional relief model of the project area (Rambaldi & Callosa-Tarr, 2002). It is clear to certain stakeholders what the depths of the sea and height of elevated areas are. After creating the three-dimensional model, stakeholders engage in a process to create a legend and other content using locally sourced materials, resulting in a visualised context for planning (Maceda *et al*., 2009). When P3DM is employed, it assumes an immersive activity that requires long-term investment by all stakeholders (Rambaldi *et al*., 2010). As the terrain is based on geo-referenced data, it is possible to incorporate the results of the activity into a GIS. GPS data can be added to the model via a geo-referenced grid that can form part of the model (Dwamena *et al*., 2011; Gaillard & Cadag, 2013).

Planning in detail before a disaster determines the success of post-disaster actions (Satterthwaite, 2011). Current planning processes that incorporate CBDRA, facilitated by consultants during piecemeal moments in time as stakeholders become available, often include an element of GIS. However, this does necessarily lead to a collaborative process (van Riet, 2009). As stated previously, in South Africa, the required CBDRA process incorporating stakeholder engagement is limited by current practise (Reddy, 2010; Wentink & van Niekerk, 2017; Mtshengu, 2017). A PGIS method that inherently incorporates the participation of relevant stakeholders (Dunn, 2007; Corbett & Rambaldi, 2011) could enhance the standard disaster planning process.

P3DM is inherently collaborative and focuses on incorporating knowledge local to an area in disaster planning. Creating a model of a project area (Rambaldi & Callosa-Tarr, 2002) is the first collaborative step that needs to be undertaken in preparation for a participatory workshop. After creating a 3D model, stakeholders in the activity create a map legend and other content using local materials such as string and push pins (Rambaldi & Callosa-Tarr, 2002; Maceda *et al*., 2009). In projects where P3DM has previously been used, the 3D model helps stakeholders communicate their knowledge of the study area (Ramirez-Gomez *et al.*, 2017). Due to P3DM activities, plans have been adjusted to make them more realistic, where previously, community members were not concerned about accurate planning (Bourgoin *et al.*, 2012). As the model is georeferenced, any data created can incorporate spatial data and be exported to an external GIS (Dwamena *et al*., 2011), as discussed in Section 7.2. The resulting data should be owned and retained by the stakeholders involved in the activity (see Section 6.4).

2.5.Knowledge Sharing Enhanced through using P3DM

When assessing several challenges experienced in the sharing of knowledge about disasters between SK and LIK in communities, community-oriented solutions are available. Participatory techniques that encourage collaborative decision making can provide solutions to shared challenges. Relevant to this project was that this could occur through disaster workshops. Research question 6 requires an assessment of the international experience in which P3DM enhances knowledge sharing about disasters.

2.5.1. P3DM Enhancing Knowledge Sharing

When disaster risk management planning occurs in a community, all workshop participants must understand the geographic context (Guillemette *et al*., 2017). Participants in P3DM activities have experienced an enhancement in their understanding of the geographic relationship between infrastructure and varied land uses (Dwamena *et al*., 2011). The tangible model provides an overview of natural hazard vulnerability and opportunities (Cadag & Gaillard, 2012). The geographical location of stakeholders is clarified, and gaps in resource allocation can be assessed by adding elevation to the model (Dwamena *et al*., 2011).

Based on the experience of P3DM since the early 1990s in East Asia and its recent use in the Global South, such as the South American and African continents, there are themes that commonly feature in the introduction and implementation of P3DM. The activities were first used in small island communities that assisted stakeholders in adjusting their plans collaboratively (Maceda *et al.*, 2009; Cadag & Gaillard, 2012). While there are examples of the use of P3DM activities on the African continent in Kenya (Rambaldi *et al.*, 2007), Ghana (Dwamena *et al.*, 2011), Uganda (Muchemi, 2016), and Tanzania (Johnson *et al*., 2022), every country has unique situations that will impact the effectiveness of P3DM activities.

These activities require several weeks of community and stakeholder time and are usually facilitated by external experts. This means that events occur outside local government officials' standard processes (Rambaldi *et al*., 2010; Gaillard *et al*., 203; Dovarch, 2017). Typically, P3DM is introduced by outside consultants using international aid funding. P3DM activities are commonly implemented in response to a perceived need in the community, whether land use planning (Rambaldi *et al.,* 2000; Bourgoin *et al*., 2012; Guillemette *et al.,* 2017; Best *et al.*, 2021), transfer of cultural heritage between generations (Rambaldi *et al.,* 2006; Rambaldi *et al*., 2007; Dovarch, 2017), or disaster planning

(Gaillard & Maceda, 2009; Dwamena, 2011; Texier-Teixeira *et al.*, 2014; Trejo-Rangel, 2020). The fact that contexts in which P3DM has been used does not reduce the impact of the implementation process. Several organisations that implement P3DM have produced manuals. They describe similar processes for designing and implementing P3DM activities based on differing needs and international locations.

Descriptions of projects where P3DM activities are implemented, as recounted in international original research articles, have several common components. These projects occurred through a large research team composed of experienced outside experts in P3DM and local non-governmental disaster professionals (Cadag & Gaillard, 2012; Dwamena *et al.,* 2011; Dovarch, 2017). The process of P3DM implementation takes many days (12 in Vietnam in 2001, 10 in Vietnam in 2003, 11 in Fiji in 2005, 30 days in Cape Verde in 2014). Months of preparation are commonly required to introduce the concept to all stakeholders and mobilise participants. The projects involve outside experts who are invited by a non-governmental organisation or a government department from the location where the project is to occur. This means that the concepts of P3DM are already known and introduced to those who invited these teams and gathered the financial and material resources required to implement P3DM activities (Rambaldi & Van Lanh, 2003; Rambaldi *et al*., 2006). Rambaldi and Callosa Tarr (2010) indicated that P3DM was institutionalised in the Philippines and was becoming the best practise there after only being introduced a few years earlier (Rambaldi & Van Lanh, 2003).

P3DM has been used internationally in projects seeking to encourage LIK use (Gaillard *et al*., 2013; Texier-Teixeira *et al*., 2014; Kusratmoko *et al*., 2017). These types of projects require much time in the field for LIK to embrace the P3DM activities and for large research teams to drive the process (Gaillard *et al.*, 2013; Kusratmoko *et al*., 2017; Ramirez-Gomez *et al*., 2017). P3DM activities require resources that are understandable to communities, yet the locally sourced materials need to be modified based on the P3DM requirements in a project (Rambaldi & Callosa-Tarr, 2002; Rambaldi, 2010; Gaillard & Cadag, 2013). This is a time-consuming exercise (Hayashi *et al*., 2021). Every time P3DM activities are initiated in a community, there is a hesitancy from the community that needs to be overcome (Hayashi *et al*., 2021). In addition to community hesitancy, low-tech methods are met with scepticism from government officials (Gaillard & Maceda, 2009; Texier-Teixeira *et al*., 2014).

In a project in rural Australia, when implementing P3DM activities, it was clear that excluding certain stakeholders (such as teachers and students) who were expected to take over the 3D model when

completed created an obstacle. The community members also found it limiting to collaborate with a physical model because their understanding of their area exceeded the dimensions portrayed by the model itself (Hayashi *et al*., 2021). The Cabo Verde experience shows that when communities are not part of the planning stage, their participation can be negatively affected (Texier-Teixeira *et al*., 2014). Good facilitation determines the success of implementing P3DM (Best *et al*., 2021).

In Suriname, greater participation incorporating training and support improved the chance of success of implementing a new method (Mirvis *et al*., 1991; Best *et al*., 2021). Expectations must be managed during the implementation phase (Mirvis *et al*., 1991). In Suriname, the expectation of communities who have provided input into the P3DM process that their input would influence decisions means that P3DM activities need to be incorporated into an existing disaster management process rather than stand-alone events (Ramirez-Gomez *et al.,* 2017).

The needed involvement of communities can be a challenge when their priorities differ from those of the project research team. Research interest and support from the relevant municipal disaster officer does not guarantee interest from community members (Texier-Teixeira *et al*., 2014). People who live in the area who have recognised LIK concerns with natural hazards do not necessarily prioritise these discussions and involvement in P3DM activities over their daily livelihood challenges. It can be challenging to ensure that all attendees of a P3DM workshop are engaged and participate as much as desired (Texier-Teixeira *et al.*, 2014; Guillemette *et al.*, 2017).

2.5.2. P3DM Enhancing Knowledge Sharing concerned with DRR

International DRR agreements encourage community ownership of DRR planning processes in the design, data collection, research definition, method development, analysis, and reporting of research (Aitsi-Selmi *et al.*, 2015; Tozier de la Poterie & Baudoin, 2015). The agreements desire LIK use when disaster planning occurs. P3DM activities that improve compliance with these agreements create an opportunity for increased use of these activities. In response to Question 6, it is necessary to assess how P3DM in international projects contributes to the sharing of disaster knowledge.

P3DM activities have been used internationally to encourage knowledge sharing during the CBDRA components of disaster planning. There are many reports about the added value of using P3DM for sharing between knowledge types. Those working in the disaster management field understand the need for community input to evaluate and reduce the risk of disaster. The potential for a community

activity that empowers people and enables the use of methods acceptable to the community is recognised. The activity for knowledge sharing needs to enable common ground for sharing of knowledge between stakeholders (Gaillard & Maceda, 2009). Opportunities are created for sharing knowledge through P3DM in a way where all participants are present and contribute their content (Kusratmoko, 2017). The researchers recognise the value of sharing knowledge of the community not only with NGO facilitators but also with other stakeholders in CBDRA. Through good facilitation the power imbalances can be managed.

2.5.3. P3DM Enhancing Knowledge Sharing and Increasing Participation

Drivers of international development projects who desire increased participation have motivations including politics, ethics, and improving project success (Chambers, 2006; Bande *et al*., 2024). International P3DM projects are often driven by international agencies seeking to improve the development of the area. Sustainable DRR benefits from stakeholder co-operation (Cadag & Gaillard, 2012). A greater understanding of the context in which communities live could translate into greater participation in other planning activities and greater community cohesion and resilience in times of disaster (Maceda *et al,* 2009; Gaillard & Maceda, 2013).

Research interest in P3DM was driven by reading about Arnstein's ladder of citizen participation (Arnstein, 1969) and Choguill's adaptation for developing countries (Choguill, 1996), with DeGraff and Ramlal's (2015) participation levels being a more recent statement of the levels, as shown in Figure 2-2. More participation is desired to ensure useful results of the interaction during the research for the project and others involved in the P3DM introduction events. The legislated desire for wider stakeholder participation can be gained through P3DM.

Figure 2-2 Levels of Public Participation (DeGraff & Ramlal, 2015)

Stakeholder involvement through advanced levels of participation can be of greater importance than the results of the activity because community members need to define what is required from the process (Panek, 2016). Community incorporation of LIK and involvement in the design, process and analysis of the project enhances the collective action, thereby achieving a higher level of participation. However, if a project is purely aimed at the benefits for outsiders without long-term beneficial impacts for the community, the desired more advanced participation level is not achieved (DeGraff & Ramlal, 2015). P3DM activities benefit from higher levels of participation. Good facilitation during P3DM workshops where LIK is added to a blank model leads participants to add content sequentially. The sequence of adding LIK in a participatory manner benefits from facilitation using mental mapping. Participation is encouraged in P3DM activities through community members being encouraged to share their LIK. Participants in a P3DM workshop are guided to first share their knowledge of local landmarks, including social facilities, and then road links between these natural landforms (Rambaldi & Callosa-Tarr, 2002; Rambaldi, 2010).

Researchers using P3DM activities are aware of certain threats to knowledge sharing activities. Workshop participants could provide confidential input into the P3DM model, which is not meant for outside consumption. These ethical concerns are important to consider when introducing a novel participatory method like P3DM (Fox *et al.,* 2006; Gaillard & Maceda, 2013).

2.6.Conclusion

When considering the contribution of a novel method to enhance the use of LIK in CBDRA workshops in South Africa, the theoretical background to the challenge needs to be considered. Based on the research objectives and questions, various aspects of LIK and the benefits and challenges of sharing knowledge need to be examined. This theoretical grounding allowed the methodology governing the practical component of the project to be reported. The next chapter details the methods designed to assess whether the international experience of P3DM enhancing knowledge sharing can be applied to standard CBDRA practises in South Africa.

3. Methodology

This chapter discusses the methodology and methods used in this research project. This project in the objectives and questions (see Section 1.1) required the introduction of participatory three-dimensional modelling (P3DM) activities to government officials and private consultants. Several

questions have been responded to in chapters 1 and 2. Questions 5 and 7 require field work using the methodology described in this chapter. Before deciding on the methods of research, the background and assumptions underpinning the methods need to be examined. These methods included a single case study occuring at multiple locations during which data were collected. The single case represented an unusual case in which the situations deviated between the multiple locations and differed from expectations based on academic literature and consultant engagements.

As stated previously in Section 1.3, there were multiple challenges in choice of methodology. These challenges are discussed further in Section 6.2 and 6.4 Introducing a new method, such as P3DM, to an organisation with existing standard processes was challenging. This challenge was highlighted in developing a coherent methodology to undertake the study. The scope and focus of the study became clearer using a progressive case study design. This meant that the methodology could be developed as a result of previous experience. This freedom to develop the project over time also was challenging as the methodology could not be explained to participants and stakeholders in advance. An advantage in progressively developing the methodology meant that the participants became more fully part of the process. A less top-down methodology meant that participants could influence the study results and therefore the data collection would not be as objective as research in a laboratory. This influenced a desire for methods increasing scientific rigour, see table 3-1, to increase the reliability of data. This was a means to respond to the methodological challenges inherent in this type of field work study.

Justifying these choices of methodologies and methods is the aim of the first portion of this chapter. This includes a description of the motivation for the progressive case study research design, case study choice, and methods, including semi-structured interviews and observations emphasising deeper trustworthiness.

3.1. Optimal Research Design

Yin (2018) stated that when conducting empirical research on a contemporary situation in a real-word context, a case study methodology is appropriate. To achieve the optimal research outcome, this project has combined the deductive case study method with the inductive grounded theory approach in an approach known as the progressive case study approach (Steenhuis & de Bruijn, 2006).

The project was initiated on the basis of international case studies using P3DM. This study aimed to determine whether this novel method for enhancing communication about knowledge to reduce the risk of disaster could be introduced in South Africa. This question was evaluated using the deductive methods of a case study. Questions to be asked of participants in workshops were designed before data collection occurred. However, the data collection process that used flexible pattern matching, case study observational research, and an iterative process to analyse the data were more in line with inductive methods. The next sections briefly describe the deductive and inductive methods that are well established in qualitative research, followed by a pragmatic approach and finally, the optimal method called progressive case study design.

3.1.1. Case Study Method (Deductive Process)

The project used a post-positivist exploratory case study. In line with Yin (2018), methods are employed to ensure rigour, similar to those used in experiments. The research design could use techniques to ensure that scientific rigour (Lee, 1989; Gibbert & Ruigrok., 2010) is applied thoroughly and effectively. Case studies in the post-positivist view are deductive, in that they can be evaluated, and aim to be objective. There is a desire for case study protocols to ensure that case studies can be replicated. Similar methods need to be used at each location in the single case study.

Clear measures of research quality include construct validity, internal validity, external validity, and reliability. Existing literature is read to develop the set of questions that are evaluated through the case study. Case studies are carefully selected based on particular criteria at the start of the study based on established theory. Assessing the research aim stated at the start of the study follows methods that allow for replication of the process. Analytic generalisation is the aim of this study. Research benefits from pilot studies that are not always part of a complete case study (Yin, 2018).

3.1.2. Grounded Theory Approach (Inductive Process)

An alternative perspective is an emergent interpretive case study method developed by Glaser and Strauss in 1967 that has been further developed since then (Steenhuis, 2015). This method is an inductive process in which the researcher interprets reality on the basis of interactive data collection and analysis processes that occur simultaneously. Theory is developed through processes, including data coding. Theory is developed based on the collected data (Steenhuis and de Bruijn, 2006). Only after the collection of data has led to theory should any literature be ready in the specific area being researched.

There was a desire to not have preconceived notions and expectations regarding the case study process. First, the theory needed to be developed on the basis of the data before reading the relevant literature. Being open to various understandings of the situation was crucial when following the grounded theory approach. There was no need to replicate cases because one case informs the choice and method for the next case. Additional cases are useful for new insights, which means that the number of cases cannot be stated when a study is initiated (Steenhuis, 2015).

3.1.3. Planned pragmatic case study (Pragmatic)

Eisenhardt (1989) proposed an alternative to these extremes in the case study method. This approach follows the deductive selection of cases early in a project before initiating any field work. This approach uses inductive methods (Steenhuis and de Bruijn, 2006). The theory is then developed from field work data collection. However, generalisability and research validity are important in the pragmatic method. An increase in the confidence level of the research is gained using multiple sources of evidence that could be produced from multiple observers.

Literature can be used before field work, meaning that theoretical propositions are developed at the start of a project. This is done to reduce being overwhelmed by large data volumes. Cases are selected on the basis of theory. Replication is desired on the basis of well-defined methods, including interview schedules. However, data collection and analysis occur simultaneously. Single-case analysis requires writing up and describing what has been observed. Cross-location analysis is useful for describing patterns derived from the data. Multiple locations are comparable using similar methods (Steenhuis, 2015).

3.1.4. Progressive Case Study

Steenhuis and de Bruijn (2006) recognised how different these three approaches are. The differences are not purely concerned with ideology but also with the place of literature, analysis techniques, and other methods available to researchers (Steenhuis, 2015). Triangulation of data sources can remedy the weakness of subjectively collecting and interpreting data (Steenhuis and de Bruijn, 2006). When collecting data for a topic not previously studied in a particular context and analysing the collected data iteratively, a progressive case study can be powerful (Hentschel *et al.,* 2018). There is an advantage in using this iterative process of asking more questions and changing methods to suit the results of the data collected (Capacio *et al.,* 2021).

When combining the deductive and inductive methods, while following the pragmatic case study methods, it is possible to replicate a case, and there is openness to new insights based on the collected data (Steenhuis, 2015). This means that modification of mindset and appropriate adaptation was possible based on the research experience on the ground as appropriate for disaster risk management research when working with communities (Few *et al*., 2022). For this project, a version of the progressive case study was employed. The credibility of the results is important in this ideology. This involved triangulation of data sources and checking the results with the informants. The quality and scientific rigour of the research design was improved by applying techniques (Lee, 1989; Sarker & Lee, 2003; Yin, 2018), as detailed in the text and summarised in table 3-1 below.

Table 3-1.: Techniques to increase scientific rigour (Sarker & Lee, 2003; Yin, 2018)

Criterion	Guidelines from the Literature	Whether or how the guidelines were applied in the study
Internal Validity	Pattern matching	The predicted results were matched with empirical results. Rival explanations were considered
	Time-series	Track the interaction of workshop participants through cameras and video footage in events where the start and end points are unclear in all workshops
	Cross-location analysis	Develop arguments supported by data to compare elements of different studies
Construct Validity	Using multiple sources of evidence	Survey questions with multiple community members, interviews with officials, documentary evidence, and observation
	Having key informants review the case study report	Disaster officials reviewed the P3DM activities process before the workshops and a draft version of the case study reports
	Establishing a chain of evidence	Detailed processes to be followed developed, meeting notes maintained, and regular updates communicated with supervisor and relevant colleagues
Reliability	Creating and maintaining a case study database	Case study notes (annotated transcripts) Case study document (questionnaires, introductions) Case study of P3DM workshops Case study narrative
	Developing a case study protocol	An evolving set of questionnaires; literature review; proposal; introduction of P3DM to officials and consultants
External Validity		

	Increasing degrees of freedom	Test rival theories; multiple observations for each prediction; multiple locations
	Applying replication in logic/analysis (not sampling/statistical logic)	The same questions were asked of officials after P3DM workshops in different study locations; to evaluate the same objectives

3.2.Case Study Site Selection

When the methodology was developed for this research, there was a need to select a case for study. The case to be studied needs to be current and needs to be studied in its natural context using various methods (Benbasat *et al.*, 1987; Yin, 2018). Knowing that a case is a complex functioning unit that could best be studied through case study methodology (Johansson, 2007; Yin, 2018). The case, developed at uMgungundlovu District Municipality (UMDM), was derived from the questions to be assessed (Curtis *et al*., 2000). It was decided to apply the case study methodology at four locations (Impendle, Camperdown, Howick West and Lidgetton, see figure 4-1) within UMDM.

This study assessed research questions regarding the introduction of P3DM to officials. Using a single case at these four locations ensured a rigorous research design and analysis process using a multiple-location design. Using multiple locations boosted the results from the different locations in the study (Zainal, 2007), although this process was more costly in terms of time and other resources. Multiple locations during the study allowed greater clarity in contextual variations between the locations. On the basis of the deductive case study theory, selection criteria were developed (see list below) that led to single-case multiple location field work occurring in UMDM. Based on these criteria, there were four locations for workshops where P3DM could be introduced.

Field work research of this nature cannot occur without an invitation from government officials at the desired location. In terms of South African disaster management legislation, only the local government officials in an area can arrange disaster management community workshops. The openness and permission of the officials is critical to the success of the project.

Criteria for suitable single case at multiple locations:

- Openness to research by UMDM officials
- Access to disaster management officials interested in the project

- Disaster management officials already using LIK in community engagements
- Frequent occurrence of natural hazards
- Communities that have lived in the location for several generations
- Research team members' familiarity with the language and culture of the community in the desired workshop locations

Practical considerations existed to support the choice of the pilot study location (Yin, 2018). The selected location, Impendle Local Municipality, is close to Pietermaritzburg, where the most relevant UMDM district officials are based. Prior knowledge of the community existed with a member of the research team. Participants in the P3DM activities remembered their experiences of recent natural hazards. This prior knowledge was strengthened through activities with community members at their community hall to build a three-dimensional model base that was used in the final P3DM workshop. As requested by the officials, the pilot study was conducted as requested in Ward 2 of Impendle Local Municipality (see figure 4-1).

The population in UMDM was appropriate for planning to prevent disasters that needed to occur through CBDRA workshops. The units of analysis (Benbasat *et al*., 1987) were disaster planning officials who arranged workshops at UMDM. The research presented through this dissertation considered P3DM use in disaster planning within UMDM because of the researcher's prior interest in P3DM use in disaster planning, a desire to replicate theory used in international projects to a local situation, and prior contact with government officials within UMDM who could facilitate the data collection process. The rigorous methods described in the previous section are important for generalisation (Yin, 2018). Table 3-2 indicates the number of participants involved in the study.

Table 3-2.: Number of participants involved in the study

Type of participant	Number of participants	Interviewed
Community members	40	20
Municipal volunteers	60	0
Municipal officials	15	4
NGO members	2	1
Consultants	4	4

Section 4.3 of this dissertation describes the roles of these participants. Due to the small number of participants in the single case study in multiple locations, the research described in this dissertation employed analytic rather than statistical generalisations (Yin, 2018). The principles of the case study

results lead to lessons learned that could be applied to other similar situations in the future. At the outset of the study, propositions were developed that, whether corroborated by the results of the study or not, could be applied based on developed theory and analysis. There is an expectation that the multiple locations where workshop events occurred, in Impendle, Camperdown, Howick West, and Lidgetton, could be repeated elsewhere in the country (Ragin, 1992; Yin, 2018). The desire to be able to repeat this process of introduction elsewhere assumes that there are other areas that are sufficiently similar is common in case study research (Ragin, 1992; Lund, 2014). As the study progressed it was clear how unusual this case at UMDM was due to an acceptance of the value of LIK by disaster management officials at this location.

3.3.Pilot Case Study

To develop the instruments of the research, as designed, a pilot or feasibility process was implemented. This process added value to the superior design and the opportunity to assess aspects of the research. This enhanced the likelihood of success of the study without guaranteeing any results (van Teijlingen & Hundley, 2001; Yin, 2018). The pilot study allowed the testing of aspects of the intended main research project. The size of the population surveyed, location of the data collection sites, testing of interview questions, and other case study methods were evaluated through a pilot study. It can also be an opportunity to train research assistants. As a result, the viability of the research method could be assessed (Lancaster *et al*., 2004; Hassan *et al*., 2006; Doody & Doody, 2015). The pilot study also included the recruitment of participants (Hassan *et al.,* 2006). Other stakeholders could be convinced of the value of the main study based on the pilot study (van Teijlingen & Hundley, 2001).

There were concerns to be aware of regarding the use of a pilot study. A limitation is that predictions are made purely on the basis of the pilot study. Success in the pilot study cannot guarantee similar success for the full-scale study that could follow. As a result of the pilot study, there could be major changes in the research protocol (van Teijlingen & Hundley, 2001; Cope *et al*., 2015) based on the pilot study learnings. Research participants in the pilot study when involved in the full-scale research later on could change their behaviour between studies. They would become familiar with the methods and could be less likely to follow the research protocols because of respondent fatigue. The concern here was that certain participants have more experience than others. However, due to the small sample size, it was not possible to exclude participants from the full study (van Teijlingen & Hundley, 2001; Cope *et al*., 2015).

During the pilot study, a method for building a 3D model was developed (as described in Section 4.4). Details of these practises were sourced from videos and training manuals produced through various P3DM. Models based on 20-m contour lines printed on one A2-sized page were produced. The paper with contour lines was placed on a sheet of cardboard. The cardboard sheet was cut to fit an A2-sized page. Based on the contour lines, the carboard sheet was cut and the layers were glued onto each other. After waiting for the glue to dry, sheets of toilet paper were placed onto the layers of cardboard to create a gentler sloping effect. White paint was then added to the model to create a consistent base that would now be ready for LIK to be added. Toilet paper was then attached to cardboard with glue. Having developed the method to produce a 3D model meant that it was easier to introduce P3DM activities to the workshop participants and facilitate their learning about the process.

3.4.Methods of Data Collection

What was desirable in case study research rigour is the use of multiple methods to provide an understanding of a situation in its context. Different research strategies were combined to enhance this understanding and improve the validity of the case study results (Johansson, 2007). Multiple data collection methods ensured that the results were authenticated (Eisenhardt, 1989; Yin, 2018). Multiple sources of data, including documentation, interviews, and field observations, meant that diverse sources provided support for each other (Yin, 2018). The elements of data together provided a holistic view of the study that illuminated the strands of the case (Baxter & Jack, 2008). The sections that follow elaborate on certain sources of data collected. The added value and weaknesses regarding the data sourced during the research detailed in this dissertation can be assessed.

3.4.1. Documentation

Documentary evidence was used to support other sources of evidence and verify the veracity of the data collected. Documents were reviewed as required. Documentary data were both broad and specific to the location and needed to be assessed for inherent bias (Yin, 2018). Documents in the form of disaster sector reports and relevant components of integrated development plans from local municipalities and the UMDM were available for use.

3.4.2. Interviews

Semi-structured interviews were used in this study. The questions were asked to enable an understanding of the perspectives of the research participants (Yin, 2018). The method and process

of interviewing depended on the theoretical background of this project. There are best practises in interview techniques that are described in the following subsections as used in this study.

i) Sampling of interview participants

The development of an appropriate sample relevant to the project was important for the validity of the project (Curtis *et al.,* 2000; Noy, 2008). The sampling method was iterative using snowball sampling techniques and was developed during the project. As the project sample consisted of officials at UMDM who had never heard of P3DM, there were challenges in preparing the participants for the project. Potential participants in the research nominated others who could be relevant to the project, this required social networks and referrals to be in place (Biernacki & Waldorf, 1981; Farrugia, 2019). It became a process that developed independently of the researcher (Biernacki & Waldorf, 1981). This method, known as snowball sampling, was found to be flexible in developing contact with the research participants.

This meant that there was a selection bias as those who were interested in the project became participants who invited those whom they knew. There could be concerns about the generalisability and validity of the results obtained using this method (Parker *et al.,* 2019). Another challenge was that referrals came from friends and colleagues who may not have been appropriate for the project if they were not knowledgeable about disaster management. The snowball sampling manner meant that the participants may not have been representatives of the entire population of UMDM officials. In terms of replicability in South Africa, the research participants in UMDM were not necessarily representative of all South African officials aiming to reduce the risk of disaster. This is part of the discussion in section 6.2 of this dissertation.

Community members were relevant to the study process as stakeholders in community disaster workshops. There were questions developed to be asked of them. The assumptions (section 1.3) about community members that they have LIK concerned with disaster and are willing to communicate their knowledge needed to be assessed. There was an interest to check whether the community members who typically attend standard disaster workshops have lived in their area for several generations and have knowledge about disasters.

ii) Interview questions

Questions of community members were asked to better understand the demographics of these respondents (see Appendix B). Other research has found that gender, educational achievement, and religious beliefs influence understanding of and response to disasters (Bonanno *et al*. 2007; Donner & Rodriguez, 2008; Wisner, 2010). The demographic questions were designed to be at the end of the set of questions to reduce concerns about sharing personal information (Lietz, 2010). The methods of asking questions needed to be relevant to the research questions and the desired analysis. For community members this involved going through a list of prepared survey questions.The results were ready for qualitative and quantitative analysis (DiCicco-Bloom & Crabtree, 2006).

Consultants who have an understanding of the disaster management field in South Africa were relevant to the study. Open, unstructured questions could be asked of these participants where there was no idea in advance on what should be focussed on and sufficient time and great depth of material was required (Gill *et al*., 2008). The consultants added texture to the study through their knowledge of UMDM standard community disaster workshops and also the standard processes in other parts of South Africa. Through the online conversations they could confirm an understanding of South African disaster legislation and consider opportunities to introduce P3DM.

iii) Semi-structured interviews

These interviews of government officials (see Appendix C) allowed for greater flexibility as there was guidance for a conversation that did not limit unexpected input from the participant. A list of focussed questions was prepared in advance to allow for a wider discussion. The researcher needed to be well prepared and attentive to understand when and for how long to deviate from the prepared set of questions (Gill *et al*., 2008).

3.4.3. Field Observation

Field observation required the research team to be alert while conducting the study. The behaviours of participants needed be noted and examined (Cowie, 2009). Every member of the research team played an observational role. While the project was taking place they could develop questions and investigate the activities under study (Gold, 1958). Analysis of the process of the workshops occurred during and at the end of every workshop. The progressive case study approach meant that each

workshop built on the previous event. Observation allowed an experience of the context of the field work study that, while not always avoiding error in bias or interpretation, encouraged the research team to revise and adapt to changing situations. Limitations are noted in merely semi-structured interviews, which can lead to countless errors (Becker & Geer, 1957). For this reason, supported by Yin (2018), the observation role in addition to the semi-structured interviews was used among the multiple methods of data collection.

Observations were reported in detail. Listed here are certain dimensions of observation that were relevant in assessing the observations. According to Cowie (2009), certain key dimensions are relevant for assessing the observation. These are space, actors, activities, objects, acts, events, time, goals, and feelings. Space relates to the physical place(s) where the observation occurred. Actors are the people involved (observers and subjects). Activities are sets of related acts undertaken by the actors. 5Objects refers to the things physically present. Acts refer to the actual actions of the participants. The events are the series of connection events performed by participants. The results of this observation process can be viewed in table 5.1 as part of Section 5.1.3. There was also a time component of any observation that allowed for time-series analysis. Goals to be accomplished occurred over time. The observation process included feelings as emotions were expressed and felt by workshop participants.

The observation concerned all participants in the workshop events. Community members who had their LIK developed over generations of living in the area could be observed in their learning to make three-dimensional models. The process in which they became more involved in the process of adding their knowledge of natural hazards to the models they built was observed. Consultants and ward councilors were observed for their role in the P3DM activities to understand their role in the discussion of knowledge of disasters. Municipal officials concerned with disaster management were observed in their leadership role of community disaster workshops introducing this new method. Their level of acceptance and understanding of the added value – their perception of the value of P3DM – would answer the final question of the study. P3DM benefits can most easily be perceived when all stakeholders are present at one time and can be observed in their interaction with each other as knowledge types are shared.

3.5.Methods of Analysis

Analysis of a single case study in multiple locations required studying the outputs of diverse data collection tools. The development of methods to analyse the results before collecting data is explained here (Yin, 2018). Using an approach developed by Morgan *et al*. (2017), the observation of participants in workshops preceded a semi-structured interview data collection process (figure 3-2).

In terms of the case study observational approach (Morgan *et al*., 2017), initial analysis occurred during the workshop events. Analysis of a single case study in multiple locations was an iterative process (Ellram, 1996) using case study observational approach. The analysis process was initiated during field work data collection while the workshop events were observed. This leads to an iterative process between data collection and analysis.

Observations were analysed in a preliminary manner during and after the workshop events. The case study notes produced during these events assisted in this analysis process. The research team discussed and analysed the process to be followed. With the introduction of a new participatory method to disaster officials, observations at varied workshop locations could be analysed. Benefitting from the progressive case study approach, the research team could develop a method of introducing P3DM, refining that analysis process from one location to the next. In addition to using certain strategies that assist the analysis of a single case study in multiple locations, there were analysis methods to implement (see section 5.1.3).

Pattern matching, explanation building, time-series analysis, logic models, and cross-location synthesis are among the available methods (Yin, 2018). Each of the available methods were considered for incorporation into the study described in this dissertation to ensure a thorough analysis.

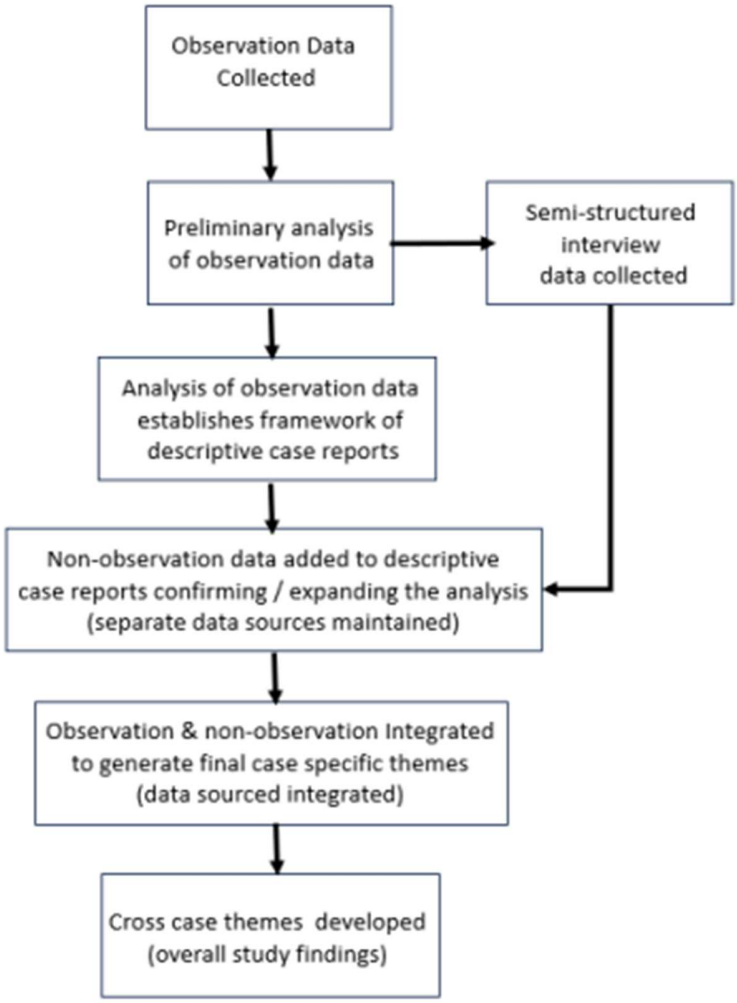

Figure 3-2 Case study observational research: Sequence of data collection and analysis. (based on Morgan et al., 2016)

3.5.1. Pattern Matching

Pattern matching is a desirable technique for analysing a case study (Yin, 2018). It involves comparing a prediction and alternative explanations, including rivals, of the outcome of a case study with the actual results (Kohn, 1997; Almutairi *et al*., 2014; Yin, 2018). This analysis method is designed to enhance the scientific rigour of a case study. When there is a difference between what was predicted and the study outcomes, alternative explanations need to be found (Almutairi *et al*., 2014). Pattern matching requires explicit stating of the predictions. In research projects, there are predictions and outcomes; pattern matching makes this more explicit (Sinkovics, 2018).

A subset of the full pattern matching method develops an iterative process to enhance theory production processes known as the flexible pattern matching approach (Bouncken *et al*., 2021). For exploratory case study research, this is an appropriate technique. A flexible pattern matching approach understands the reality of research that the initial propositions to be assessed can change during a project. These changes occur due to the cases being studied (Sinkovics, 2018).

Considering credible rival explanations to the assumptions and questions of the study was a needed analysis strategy. Certain rivals were understood before any data were collected. The data collection process, especially the interview process, identified more rivals. These rivals need to be incorporated to improve the quality of the analysis (Yin, 2018). During field work data collection, multiple locations could be incorporated to increase the usefulness of theoretical explanations (Dür, 2007). Potential rival explanations included social trends, the implementation process, or an intervention other than the one being researched as they could all influence the observed result (Yin, 2018).

3.5.2. Time-series Analysis

Analysing time-series data means that the temporal association between variables can be viewed in greater detail. The availability of time-series data means that the plausibility of certain propositions can be better assessed. The results of time-series analysis can add nuance to the other evidence collected (Fedderke & Luiz, 2007). When using time-series analysis, it is possible to track only a single measure over time within the context of the case (Yin, 2018). Other methods do not give the element of time sufficient consideration. Including time in the analysis means that successive observations can be included in the case evaluation (Gottman *et al.,* 1969). For a single case occurring in multiple locations in which a time-based process is being assessed, time-series analysis is desirable.

Time-series analysis is a descriptive method used to explain events (Gottman *et al.,* 1969; Yin, 2018). A single case study in multiple locations benefits from strong narrative and descriptive elements. These narratives are not easy to reduce into straightforward facts, figures, propositions, and theories. The richness of a case should not be ignored (Flyvberg, 2006). Using time-series analysis, the descriptive elements of the case can be enhanced. For a case where the process being studied occurs over a longer period, the descriptive element becomes especially important. On the basis of a project database maintained during the data collection process, including time can confirm observed incidents as they occurred (Gottman *et al.,* 1969). A challenge in using time-series data is that clear starting and ending points may be unclear in certain case study research projects (Yin, 2018).

3.5.3. Cross-location Analysis

If the case study strategy involves multiple locations, cross-location analysis methods can be applied (Yin, 2018). It is then possible to compare the processes, locations, or events that are the focus of the study (Khan & VanWynsberghe, 2008). Within case study research, the context of the studies is relevant to the analysis. There is then the use of a case-based rather than a variable-based approach to cross-location analysis. There are normally not enough cases to focus purely on the variables (Yin, 2018). For multiple locations, it is valuable to compare the results between the cases. As a result of the cross-location analysis, comparisons between the workshop experiences were examined. The different contexts in the different cases assist in developing evidence to support the theory. An alternative view is that the particularity of a case means that comparison is not possible for case study research (Khan & VanWynsberghe, 2008). Within UMDM, a single case had multiple locations where workshops could occur. There was value in comparing and contrasting the workshop experiences in the various locations.

3.6.Conclusion

Underpinning thorough case study research is a theory that is clearly expressed, fully described, and justified. The case study method, within the defined progressive case study approach, required well-defined data collection and analytical methods to learn from and generalise the developed theory. This chapter provides an overview of the theory and methods used in the field work described in a narrative form in Chapter 4 of this dissertation.

4. Case Study at UMDM

The narrative of the case study using the progressive case study approach described in chapter 3 is recounted in this chapter. As the research focussed on introducing participatory three-dimensional modelling (P3DM) activities to government officials concerned with disaster management in South Africa, a case was chosen according to the criteria (see Section 3.2). A chronological narrative of the field work follows.

A certain amount of planning could occur before any field work. Concrete planning was a challenge because P3DM would be introduced as a novel method to bridge gaps in knowledge types. This meant that not too much planning could be pre-conceived. Project planning was based on knowledge of the introduction of P3DM in international projects, initial expectations of standard disaster management processes at UMDM, and resources available to the project. For this project, permission to start at UMDM was granted 6 months before the first pilot workshop occurred. During these 6 months, certain planning did occur. Rather than planning the project in much detail up front, much consultation was required that occurred during this 6 month period. Bottom-up planning suited the progressive case study approach employed in this study. Meetings were arranged with local municipal officials who became research participants. Input was received from consultants in disaster management planning regarding standard disaster planning in South Africa. A research team was formed to develop a method to build a 3D model.

Due to the bottom-up, consultative, nature of the project planning, and a progressive case study approach, planning and adjustment to planning occurred throughout the project. This meant that the initial planning was adapted on the basis of consultations that occurred before and after the workshop events. The events occurred very differently compared to the initial planning in terms of not using school children and education department facilities as had been planned. The events where P3DM was introduced occurred exactly as planned when the project was conceptualised. Due to the thorough engagement with project stakeholders, these events were successful.

4.1.Description of the Field Work Location

The geographic boundary of the research described in this dissertation is the spatial extent of the UMDM family of municipalities. UMDM is located in the southwest of KwaZulu-Natal Province (figure 4-1). It is bounded by the eThekwini Metro in the east, Ilembe District Municipality in the north-east,

uMzinyathi District Municipality to the north, and the Drakensburg Mountains to the west. A highway (labelled N3) traverses the UMDM between the urban heart of South Africa in Gauteng Province and the coastal city of Durban.

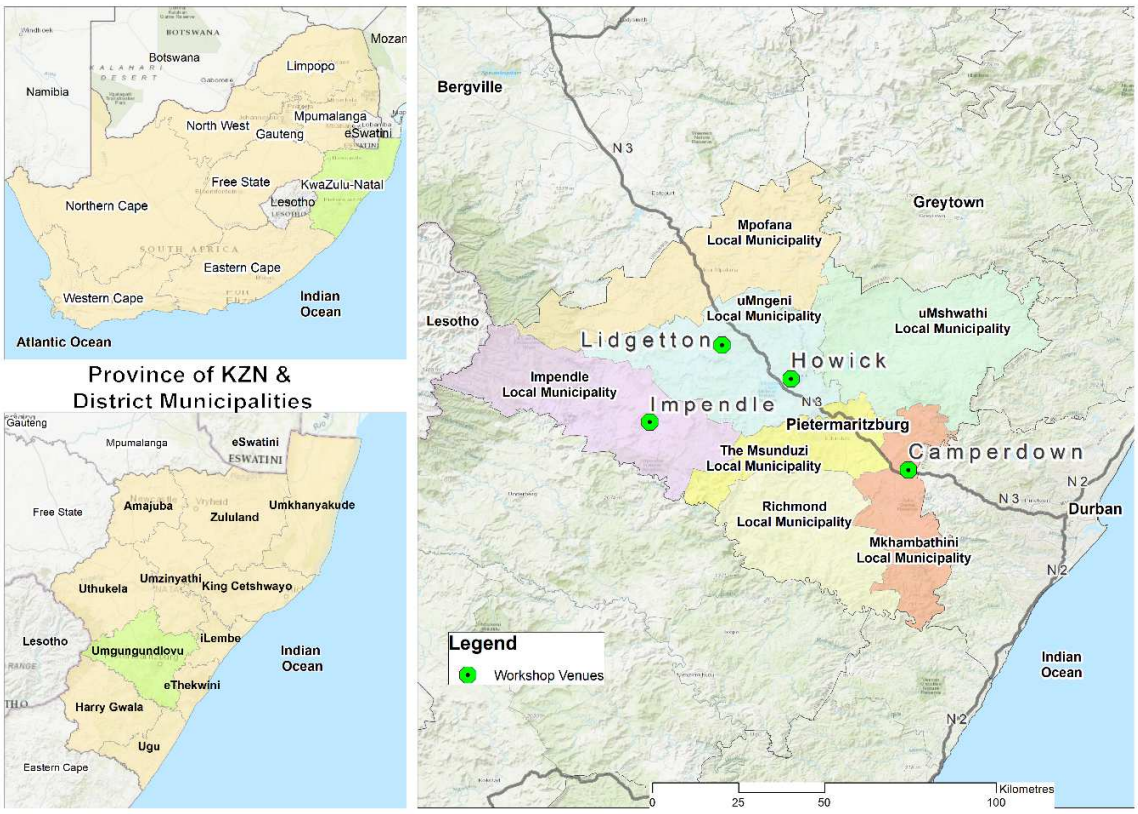

Figure 4-1: uMgungundlovu District Municipality Locality Plan

Source: Demarcation Board – district & ward boundaries, 2018

The district is made up of seven local municipalities: uMshwathi, uMngeni, Mpofana, Impendle, Msunduzi, Mkhambathini, and Richmond. It covers more than 9 500 square kilometres, where more than one million people live (UMDM IDP, 2022). Built-up areas within UMDM include Pietermaritzburg, Camperdown, Wartburg, Howick, and Lidgetton. Disaster management government officials from the UMDM are based in these areas. Table 4-1 below shows the local municipalities where the workshops occurred.

Table 4-1 Local municipalities and workshop locations

Local Municipality	Workshop Location
Impendle	Impendle
Mkhambathini	Camperdown
uMngeni	Howick West, Lidgetton

4.2.Standard UMDM CBDRA Process

The NDMF provides guidance regarding the roles and responsibilities of all levels of government officials concerned with managing disaster risk when engaging in CBDRA. The process is applied differently across all South African district municipalities (van Riet, 2009). The different applications mean that the experience of disaster management through CBDRA varies across the country. Within UMDM, there are currently standard processes developed by officials to engage with community members about reducing disaster risk through CBDRA. These processes became clear through the interview process that occurred after completion of the P3DM activities. It is relevant to understand the standard CBDRA process used in UMDM when introducing P3DM activities to be used in standard CBDRA processes to enhance LIK communication between officials and community members in UMDM.

The local government disaster management official is responsible for all standard DRR processes in their municipality. Section 1.3.1.3 of the NDMF states that the "primary responsibility for the co-ordination and management of local disasters rests with the local sphere" (COGTA, 2005: 17). The interview component of this study illuminated the details of this standard process. Local officials have targets of events concerned with DRR that drive their arrangement of activities. The targets are set at the provincial government level. When the official desires a workshop, they follow a standard process that begins by contacting the ward committees and ward councillors responsible for a particular ward. The committees manage communication and the planning of events. These events then occur in all wards of the UMDM family of municipalities, with communities from adjoining wards combined at times. Loud hailers are a method used to announce the planned workshop. Through their communication process, many community members are invited to actively participate in the events.

Officials responsible for managing DRR actively engage community members in all wards within their municipalities throughout the year. In UMDM, regular events to plan and manage the risk of disasters

occur. Refreshments, including food and drinks, are provided and transport is made available. Maps of municipal wards are taken to CBDRA workshops for community members to add their LIK about natural hazards and to educate. These events vary from awareness campaigns and CBDRA to educational opportunities. Officials include visiting educational facilities in their work activities. Documentation guiding the processes used by the UMDM government officials provided relevant background understanding. This was a source of data relevant to the project.

Question 5 considers the challenges in this standard practise of disaster planning when sharing knowledge. It is possible that the participatory ideal in UMDM, expressed in the aim of Batho Pele Principles (UMDM IDP, 2022), is merely window dressing that creates greater disillusionment (Mchunu & Theron, 2014). In 1997, the National Government of South Africa initiated Batho Pele (meaning 'People First') principles. The aim is to improve public service delivery. Community members are concerned about service delivery when they interact with government officials. When community members become disillusioned, which can be evidenced in social unrest, increasing active involvement in decision-making (Brannan *et al*., 2006) and cohesion is relevant. Understanding the implementation of Batho Pele and the programme of the Office of the Premier of KwaZulu-Natal Province known as Operation Sukuma Sakhe was relevant to understanding the context in which the P3DM introduction project occurred. Sukuma Sakhe means 'Stand Up and Build' and assists government departments in coordinating their community interventions through a ward-based approach (KZN HS, 2013). There may be a dissonance between the perception by the responses expressed in the interviews of municipal officials (that participation and use of LIK is adequately occurring) and the lived experience of community members. It is possible that the CBDRA processes followed do not resonate with the communities (Govender *et al*., 2011) and are not relevant to their lives.

As stated in Section 1.1, community members have developed varied LIK responses to natural hazards that are discussed with government officials who develop plans for DRR. An example of a response is the installation of infrastructure that can be used during hazardous events, such as lightning conductors installed at relevant locations in the UMDM. During interviews at the conclusion of the field work, disaster management officials expressed their confidence that the workshops were well organised and that all participants in the standard process were adequately expressing their LIK. This may make UMDM atypical compared to other districts in South Africa as all event attendees are encouraged to speak and share their LIK in standard UMDM CBDRA processes.

LIK use in planning is intended to enhance active, local involvement through planning and municipal decision-making structures (Van Donk, 2013). Participation opportunities must be created (Mchunu & Theron, 2014) within standard municipal structures in a manner that promotes active participation. In this context, where P3DM activities were introduced for use in CBDRA workshops to community members and government officials. With the support of district and local municipal disaster management officials, these workshops were used to introduce P3DM activities using standard processes and officials familiar with the communities where the field work occurred.

4.3.Field Work Process

The standard UMDM CBDRA process occurs in environments and communities where English is not spoken. Working in these Zulu-speaking communities where a new method needed to be introduced through facilitated workshops required a small research team to be formed. The research team was initially made up of local university students and later, the government officials focussed on DRR took on the roles of the students in introducing P3DM at subsequent workshop events. The research team changed progressively during the process of fieldwork. The students spoke Zulu, and developed an understanding of 3D-model making (based on manuals and videos made from other P3DM projects in the Global South) and methods to introduce P3DM activities. The team developed a model first based on contours on an A4 sheet of paper and later using A2 pieces of paper. There was a collaborative process of learning within the team to develop the skills required for to introduce the method. Skills development included facilitating workshops, testing interview questions, interviewing participants, communicating map-reading, mental mapping, and general geographic principles. As the government officials became familiar with the project and the P3DM activities, they could take on these research team roles. The research team was initially an external team that could then become, with local understanding of the process, local to UMDM.

The research team was formed before contact with officials or communities. This meant that at the first meeting with officials, the P3DM process was understood, and example models could be displayed to the officials. Knowing that the introduction of P3DM was occurring in the context of government officials focussed on DRR, it was desirable to consult private disaster management consultants working in the field who have experience of the DRR legislative and practical context. Private consultants could verify and clarify the field of study and advise on methods to perform the field work component of the project. The context was explored through online meetings with consultants who had been introduced to the project. The consultants were already convinced of the

value and need of integrating LIK with SK in DRR in terms of the DMA, while the standard practise of CBDRA in South African district municipalities does not always comply with this.

The consultants were interested in the project, and understood the novel concept of using P3DM for CBDRA to enhance knowledge sharing. Their expectations were that introducing P3DM to government officials would be very challenging because of the time pressures that the officials experience. The consultants were aware of the inadequate staffing at UMDM and expected the project to be met with resistance. The consultants suggested that the officials would be willing to listen about the project without giving access to communities and the workshops required to introduce P3DM. The role of local officials as gatekeepers to community members was emphasised. Any new method would need to be introduced from a higher level of governance rather than from a student who is not part of the municipal structures. As a result, the consultants expected the project was difficult to implement. They suggested focussing on the educational potential of a P3DM model building exercise that could be introduced through schools within a community. A challenging project would require ongoing relationship building with UMDM officials.

Bearing in mind the need to introduce P3DM to municipal officials, contact was made with a disaster management official working in UMDM. He arranged a meeting in June 2022 where disaster management government officials at the provincial, district, and local levels of government were introduced to the research team and the P3DM project was planned to occur within UMDM. This led to an interest in the research because of the need to develop disaster risk management plans in the UMDM family of municipalities. The attendees at this meeting decided that it was now acceptable to initiate the P3DM project in UMDM. This meant that the UCT ethics requirement of gatekeeper permission before field work could start (Section 1.2) was complied with.

At this meeting, it was resolved that at Impendle Local Municipality, the pilot study could be initiated. Even after this gatekeeper permission was granted, persistence was required to meet various disaster risk management officials to start the field work. Collectively, they expressed an interest in an introduction about P3DM activities. Relationships with district and local government officials needed to be developed before the required workshops were arranged and facilitated. Their expressed interest motivated them to arrange the desired municipal workshops, where P3DM activities could be introduced, during the last quarter of 2022 and the first half of 2023. The field work component of the research required workshops.

The DMA requires well-resourced and capacitated teams to plan to reduce the risk of disaster in all district municipalities in South Africa. District government officials support local government officials with direction and guidance as required. They do not have direct responsibility for preparing for or responding to hazard events. As natural hazards are not limited to a single local municipality, there are requirements for co-ordination across local municipal boundaries (COGTA, 2015). When natural hazards affect community members, district government officials communicate with them without being directly involved in planning to reduce disasters. District officials who attended the meeting in June 2022, where the project was introduced, were willing and enthusiastic participants in the project field work. Furthermore, they encouraged participation of local municipal officials.

The responsibility rests at the local government level for responding to all hazardous events and planning to reduce the risk of disaster in their municipalities. They arrange regular events where knowledge is shared with community members. These events include CBDRA and awareness campaigns. The national disaster management framework has designated other structures such as advisory forums and ward committees to assist local government officials in their duties. Participation of a several stakeholders in municipal disaster risk management planning, including private sector consultants, NGOs, traditional leaders, and community members, is required according to the framework. This should result in integrated participation in a comprehensive approach for planning to manage the risk of disaster. Local government officials are closest to communities that experience natural hazards, and together they need to develop measures to reduce the risk of hazards becoming disasters (COGTA, 2005). In three local municipalities of the UMDM family of municipalities local government officials allowed workshops to occur. As they organised the workshops and introduced the project and the P3DM activities, they took ownership of the introduction of P3DM. They were familiar with community members and could encourage participation by community members.

Community members who have lived in their area for generations have developed LIK regarding hazards. The NDMF recognises that community members are the first to experience the impact of a hazard. The legislation requires community participation incorporating LIK for planning (COGTA, 2005); this could be explored through P3DM activities. Speaking with community members regarding their LIK, specifically their knowledge of historic natural hazards and their learned responses to these events, was relevant to the study. Observations during all workshops focussed on community members' interest and competence when producing three-dimensional models of their

area. During the workshops, where P3DM activities were introduced in various locations, community members could be observed and interviewed, whether mature adults during the case study pilot in Impendle Local Municipality (see Section 4.3.1) or young adult municipal volunteers in Mkhambathini (see Section 4.3.2) and uMngeni Local Municipalities (see Section 4.3.3.)

Young adult representatives from communities, selected from all relevant municipal wards, were also in attendance during the introduction of P3DM during workshops. In terms of the NDMF, these representatives of wards are volunteers who communicate and plan to reduce the risk of disaster. Training of these volunteers is encouraged by the DMA to ensure that new methods and ideas can cascade through the community (COGTA, 2005). The introduction of P3DM became a training exercise for these volunteers. Local municipal officials saw the value of incorporating P3DM activities in the ongoing training of municipal volunteers. As this was understood only after the pilot study, Impendle volunteers were not included during the pilot. All subsequent P3DM activities used municipal volunteers as they are part of the standard disaster planning processes.

In international best practise for introducing P3DM, as described in Section 2.3, (and recommended by the private disaster management consultants) children are normally participants in a P3DM project (Hardcastle *et al*., 2004; Texier-Teixeira *et al*., 2014; Hayashi *et al*., 2021). Due to ethical concerns and the requirement to obtain permission from the Department of Basic Education, this was not part of the research design of the study at UMDM. In the recommendations portion (see Section 7.2) of this dissertation, the option of including children to build models of their community is discussed.

Government officials at the district and local municipal levels were important in facilitating P3DM events where the new method could be introduced. These attending officials were all concerned with the DRR. It was necessary to understand the standard CBDRA process in UMDM (as described in Section 4.2) and the context in which the project occurred. A greater understanding was developed during the project. This understanding occurred after the pilot study was completed. The pilot study workshops where P3DM was first introduced occurred in a rural area, Impendle, away from the built-up areas of UMDM.

4.3.1. Description of the Pilot Study

At the meeting in June 2022, an official of Impendle Local Municipality facilitated an open discussion between the research team and provincial, district, and UMDM family of local municipalities' officials. At that meeting, the planned P3DM activities, materials, and refreshment required were described. The potential added value of being involved in the project was explained. A small version of a three-dimensional model developed by the research team was produced to show the officials an example of what would be built during the P3DM activities. The officials collectively requested that Impendle Local Municipality be the site of a pilot study. Section 3.2 describes the choice of case study site selection.

At Impendle Local Municipality, there is a World Heritage Site and tourism potential across the Ukhahlamba Drakensburg Mountains. Craft endeavours and microenterprises also occur within this municipality. The deciduous fruit industry benefits from sufficient water and low temperatures (Impendle DSP, 2018; UMDM IDP, 2022). Historically documented records were a relevant data source. UMDM's Disaster Management Plan indicated that hazards include flooding, heavy rainfall, lightning, and strong wind. The risk ratings for flooding and heavy rainfall are far higher than the risk of lightning and strong wind (UMDM DMP, 2017). Rain, lightning, structural and veld fires, and strong wind affect communities there. This document details that the management of disaster risk should be shared with multiple stakeholders who meet during advisory forum meetings (Impendle DSP, 2018).

The research team spent time developing a model-making method based on international P3DM best practise. They learned this from videos and training manuals produced through varied P3DM projects and produced a model based on 20 metre contour lines printed on one A2-sized page. The paper with contour lines was placed on a sheet of cardboard. Based on the contour lines, the carboard sheet was cut and the layers were glued onto each other. This experience meant that it was easier to introduce P3DM activities to the workshop participants and facilitate their learning about the process.

The pilot study involved four meetings in Impendle Local Municipality where P3DM activities could be introduced.

1. The research project was first briefly introduced to community members and government officials during a workshop where other topics related to managing the risk of disaster were discussed. A member of an NGO, community members, and local and district government officials were in attendance. Research team members provided example 3D models to show the workshop participants. The participants were then invited to attend a follow-up workshop. All participants were thoroughly introduced to the project and signed the research consent letter (see Appendix A).

2. During the second workshop, community members of the municipality were trained in the process of developing 3D models. This was described as a training event to train others in their community. The intention was that these community members who knew other members of their community would learn to build 3D models. Their knowledge could then be shared with other members of their community as desired by the NDMF. Understanding locations where community members live and travel via mental mapping exercises was part of the learning exercise.

3. During the third workshop, community members with more experience in the model-making process were facilitated in the development of a larger model of their area. Research team members, now augmented by district and local government officials who had become involved and interested in P3DM activities, facilitated a model building process with community members who now had a grasp of the required process. This meant that during this workshop, there was a transfer of knowledge and experience from the research team to the officials while the community members were becoming familiar with the model building process.

4. At the fourth and final workshop, participants were guided through a procedure to develop a legend of the model they had created. Based on the collaboratively developed legend items, participants could add their LIK related to historic hazard events. Their responses to hazard events, ability to manage the risk of disaster, locations, and methods relevant to becoming resilient during the disaster period, and other LIK important to them, were added to the model built in the earlier steps. As per international experience, this was an opportunity for the participants to express their knowledge that could be shared through the P3DM activities with officials who make the disaster risk management plans for the area where they live.

The preparation and execution of the pilot case study smoothed the progress of the later full-scale study. During the pilot study preparation phase, relevant model building materials were sourced. Those involved in international P3DM experiences produced manuals that include the materials

normally required. Based on this information, cardboard boxes, paints in assorted colours, various paint brushes, several types of glue and A2 sheets printed with contours at different contour intervals were required. With a research team and the materials in place, the pilot study could then be initiated where the project was introduced in the eNguga community hall in Impendle Local Municipality.

During the first workshop, the research team and project were introduced to the attendees (see figure 4-2) in the Impendle Local Municipality. Small versions of the three-dimensional models were handed to the community members to show what was to be produced during the workshop. Having produced their own models meant that the research team could easily facilitate the initial model building by the workshop participants. Their familiarity with building the three-dimensional model was expected to ease the adoption of this new method by participants from the government and community.

Figure 4-2: The participatory three-dimensional modelling process introduced to community members

During workshop 2, the method for creating a three-dimensional model was presented. As participants began to understand the model-making method, they learned to build one model together in groups with the intention of building several models covering a larger geographic area at workshop three. Figure 4-3 A and B below show participants building models in separate groups; this was an innovation developed during the pilot. Removing a large, completed model from a workshop venue is challenging (Gaillard & Cadag, 2013). It was decided to divide the area to be modelled into multiple small A2-sized models that could be joined together to represent all of one municipal ward. The pilot study was an ideal moment to experiment with the development of multiple models.

Figure 4-3 A and B: The participatory three-dimensional model building process

The experience developed during workshop 2 assisted in the production of larger and better-quality models of parts of the place where the community participants lived during workshop 3. Community members who had attended the first two workshops also attended workshop three. Participants were motivated to attend all workshops through the provision of food and t-shirts. While building

the models, the participants discussed their LIK concerning disaster risk management. This workshop was organised to show government officials that building three-dimensional models is accessible for community members and not too time consuming. Officials, during the pilot workshops, stated that the workshops assisted them in assessing the value of P3DM activities for CBDRA.

During the fourth workshop, according to the international best P3DM practise described in Section 2.3, participants added LIK concerned with hazards and DRR. Local municipal officials facilitated all the workshops and took ownership of the P3DM activities. There was a process followed to develop the legend where the participants decided together on the legend items relevant to their area. Figures 4-4 A and B show the developed legend and one of the completed models.

Figure 4-4 A and B: Legend collaboratively created & one of the three P3DM models completed

Collective model legend development occurred during workshop four. Based on these legend items, the participants used different paint colours, pieces of string, drawing pins and coloured wool in diverse colours to map various hazardous areas. Through the research team's facilitation of the legend development process, a mental mapping exercise was used to ensure an understanding of geographic concepts, locations of community facilities, and compass directions. An understanding of the impact of elevation on the experience of natural hazards and the historic experience of hazards was confirmed. Completed models that now contained LIK about disaster risk management meant that the P3DM activities were attempted through the pilot study. During the semi-structured interviews at the conclusion of the field work, it became clear that the use of 2D mapping to express LIK was commonly used in UMDM and is also used in the standard CBDRA workshop process.

During these pilot study workshops, in addition to the disaster management officials, 40 community members, one ward councillor, two town planning officials, and one GIS official attended and provided their input to the process. A representative from the NGO Working on Fire was also in attendance. The community members were mostly female, all were in the 25 to 60 age group and had secondary education. Most officials were male with one female town planning officials, all with tertiary education. This range of stakeholders attending the workshop was ideal for introducing P3DM activities to comply with the legislated ideal for stakeholders sharing knowledge related to disaster risk management (DMA, 2005).

At the time of the pilot study final workshop, a series of survey questions were asked of community members (see Appendix B) who produced the three-dimensional models and added their LIK. After the workshops, semi-structured interviews with selected government participants occurred, which was a source of evidence (Yin, 2018) used during the study. The aim of the interviews was to discern from them of the potential value of the P3DM activities (model building and LIK workshops) to CBDRA. The interview responses of participants to the workshop showed whether, through implementing P3DM activities, participants were finding it easier to communicate their LIK and bridge gaps in knowledge types, as required by the DMA.

The workshops during the pilot allowed for detailed contextual analysis of a limited number of events (Zainal, 2007) to occur where multiple sources of evidence were collected to increase scientific rigour (Lancaster *et al*., 2004; Yin, 2018). Workshop participants provided their consent for the video-recorded meetings and the survey questions through informed consent forms. A source of evidence during the P3DM workshops was the observation of participants (Morgan *et al.,* 2017). Observation

occurred through field notes taken during the workshops, that were analysed after each workshop, and awareness of the key dimensions of observation, as indicated in table 4-2.

Table 4-2 Key dimensions of observation, adapted from Spradley (Cowie, 2009)

Dimension	Definition
Space	eNguga Community Hall in Ward 2 of Impendle
Actors	Municipal officials and community members who attended the events
Activities	Creating models and adding LIK to those models during P3DM workshops
Objects	Three-dimensional models and LIK representations
Acts	People adding LIK representations to the 3D model
Events	P3DM model building and the P3DM workshop
Time	Moments as participants add LIK to 3D models
Goals	Adding LIK to the 3D model, knowledge sharing, bottom-up disaster planning
Feelings	Emotions felt and expressed by participants

In the context of disaster risk management in South Africa, P3DM activities have not yet been introduced or implemented. It is necessary to develop the procedures required for a full-scale study in which the introduction could take place, which was the motivation for the pilot study. From the pilot, it was clear that there was a need for many adaptations between the international P3DM experience and the relevant procedures used in South Africa (see Section 6.1). In the pilot study, the research team considered the procedures used to build the three-dimensional model and the number of building materials required. The logistical challenges related to the importance of easy road access to deliver three-dimensional model materials to a workshop location were assessed. A research team could be trained (van Teijlingen, 2001) in many aspects of three-dimensional model building methods, workshop facilitation, and interview questions. The number of materials required to produce several three-dimensional models was confirmed on the basis of the procedures developed in the pilot study.

Data collection methods using survey questions and observation methods were developed and introduced (Fraser, 2018) to the research team and participants. There were opportunities to evaluate the questions (see Appendix B) before and during the pilot study. Preliminary data to assess the study's assumptions regarding LIK use and significance for disaster management planning were collected. Observing workshop participants during the pilot meant that data was collected that could be analysed before interviewing government officials (see Appendix C) after the events. Due to the responses of the research team during the pilot study, subsequent P3DM activities in the full study were streamlined. This meant becoming more efficient in terms of time and finances. It was possible to report on the project using the pilot study as an example of a full-scale study.

Government officials who attended the pilot study workshops could evaluate the interest of community participants in P3DM activities. They saw the enthusiastic involvement of community members and increased levels of participation during the activities, which encouraged officials from other municipalities to introduce the project within their areas. During the third workshop, the attending government officials discussed creating further opportunities to introduce P3DM activities. There was an ongoing interest in introducing P3DM activities in a different ward of Impendle Local Municipality. Due to the time constraints of the disaster management officials, this event could not occur. Conversations about opportunities to introduce P3DM activities in other municipalities continued. 6 months later, there was an opportunity to repeat the introduction of P3DM activities to municipal government officials in one ward of the Mkhambathini Local Municipality.

4.3.2. Mkhambathini Local Municipality P3DM Introduction

Mkhambathini is a Zulu world and is derived from eMkhambathini, which means a place of acacia trees. Mkhambathini has 7 municipal wards. Most of the municipality is rural and contains four customary housing areas governed by the Ingonyama Trust alongside commercial farm lands (Sibanda, 2022). The built-up areas in the municipality include Camperdown, Eston, and Mid-Illovo. Mkhambathini is more than 900 square kilometres in extent. Roughly 60 000 people live there with a population density of 69 per square kilometre. Poverty, inequality, and high unemployment are some of the challenges experienced in this municipality (Mkhambathini IDP, 2023).

Camperdown is the largest built-up area within one of the seven municipal wards in Mkhambathini. Camperdown is within Ward 3 of the municipality. This ward has many urbanised households and is

well-resourced. It contains a lion park recreational facility, and there are proposals to develop affluent suburbs (Sibanda, 2022). Ward 3 is less deprived (in terms of income, employment, education and living environment) than most other Mkhambathini wards (Lloyd *et al*., 2021). Camperdown hosts the municipal head office buildings of Mkhambathini and is where most of the disaster reduction planning for the communities in the municipality occurs. With the support of the relevant district and local government officials, the town hall of Camperdown in Ward 3 was where the P3DM model building activity occurred.

At Camperdown Town Hall (see figure 4-5A), municipal volunteers and district and local municipal disaster management officials of Mkhambathini participated. The venue was accessible to participants as local government disaster management officials provided transportation. Mkhambathini municipal volunteers were familiar with government officials and each other as there are many disaster management events occurring throughout the year. Participants were introduced to the materials required to construct a three-dimensional model (see figure 4-5B).

Figure 4-5 A: Mkhambathini Ward 3 Camperdown Town Hall and 4-5 B: Materials used during the workshop

Cardboard boxes, glue, kitchen rolls, marker pens, cutting devices, and scissors were all used in the model building activity, based on the pilot study. As one of the district municipal disaster officials had attended the pilot study in Impendle, he could facilitate the Camperdown event. This assisted in the introduction of P3DM activities to the participants. The volunteers were interested in learning about

the workshop. With guidance from the disaster management officials, who had become part of the research team, the building of the models was started. Observing the participant process of building the models was a source of evidence during the P3DM workshop in Mkhambathini Ward 3. Analysis of this process occurred during this event. In preparation for the workshop, the extent of Ward 3 was broken down into 10 A2-sized sheets (see figures 4-6 A and B).

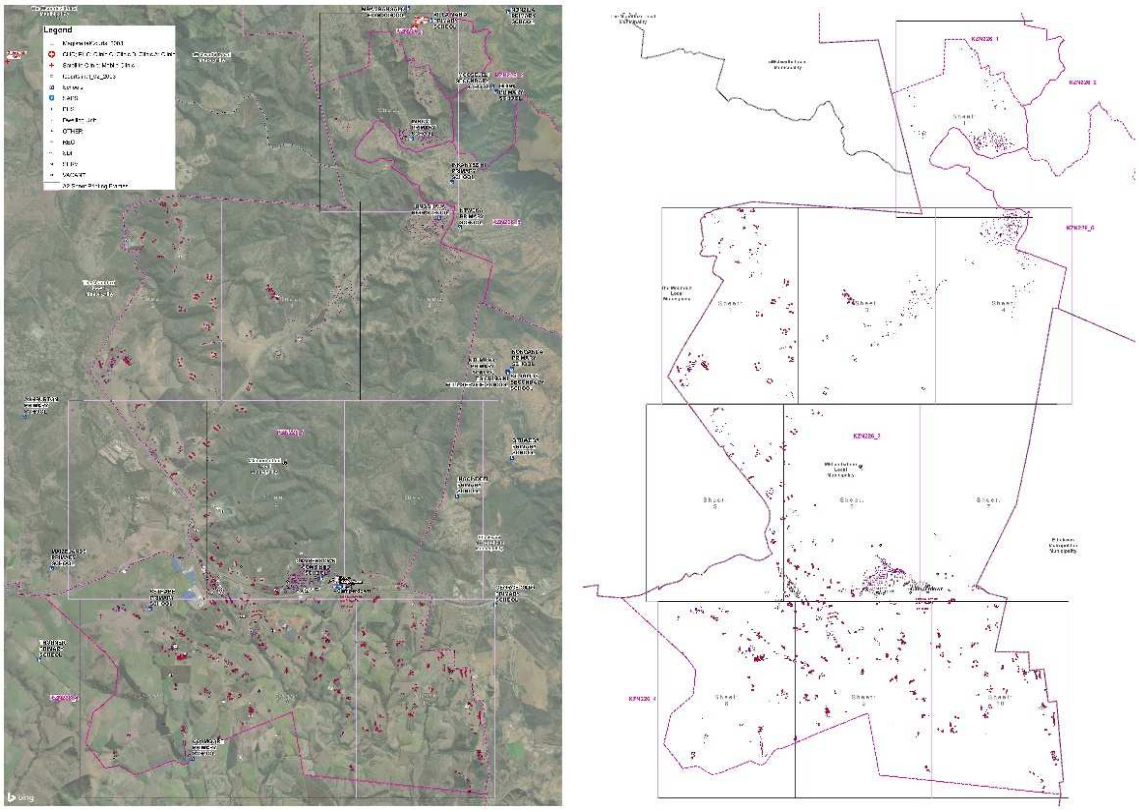

Figure 4-6 A and B: Mkhambathini Local Municipality printing sheets & imagery; printing sheets without imagery

These sheets with 20 metre interval contours displayed on them were printed out. This was the basis for elevating the models and providing them to groups of participants. During the event in Camperdown, volunteers and municipal officials took part in creating 3 A2-sized three-dimensional models. Based on the experience of the pilot study, three groups of tables were set up and teams of municipal volunteer builders were encouraged to efficiently build three-dimensional models.

After the workshop in Mkhambathini, semi-structured interviews with selected government official participants occurred, which was the second source of evidence (Yin, 2018). The aim of the interviews was to determine from the government official participants their perception of the value

of P3DM activities (model building and workshops) to enhance their disaster management processes. Respondent 3, who had supported this workshop, stated that "the visual nature enhances sharing LIK." The official expressed concern that "the current process requires several meetings with a single community." Initially, there was some hesitancy from the participants. Respondent 2 attended this workshop and noted that the Camperdown event started very poorly. It was not clear how many volunteers would arrive, which contributed to the poor start. As a result, more volunteers joined over time without an official explanation of the process that all participants understood. Figures 4-7 A and B show the model building process that occurred after all participants understood it.

Figure 4-7 A and B: Camperdown model building workshop during the train the trainer's event

The value of municipal volunteers in cascading what they learn in training to other community members became clear when discussing P3DM activities with government officials. This discussion occurred because of the successful pilot study. This meant that there was progress in the development and planning of the Mkhambathini workshop based on the analysis of the pilot study. At the model building event in Camperdown, municipal volunteers became involved as participants during what was described as a 'train the trainer model building event'.

The officials who attended the Camperdown workshop expressed an interest in introducing P3DM activities in other municipal wards of Mkhambathini. The project was to be introduced at the soon to be held disaster management advisory forum organised by the municipality. Due to their time pressures and the postponement of the advisory forum meeting, these follow-up events did not occur.

Discussions with private consultants working in the disaster management field confirm the lack of institutional capacity among disaster management officials at UMDM (Private conversations, 2022). Documents about the disaster management organisation in Mkhambathini and historic records of natural hazards were additional sources of evidence collected. It became clear that there were no further opportunities for the introduction of P3DM in Mkhambathini.

To create more opportunities to introduce the P3DM process to officials, it was necessary to collaborate with officials from other local municipalities. uMngeni Local Municipality, another municipality in the UMDM family of municipalities, is where more introduction events for P3DM activities were arranged.

4.3.3. uMngeni Local Municipality P3DM Introduction

More than 120 000 people live within uMngeni (Statistics South Africa, 2021), centrally located within UMDM. It shares a boundary with Impendle municipality, which is to the southwest. To the west is the World Heritage Site, including the Drakensburg Mountain Range. Employment is found in finance, community services, trade, manufacturing, and agricultural activities. Dairy and beef farming and the cultivation of vegetables are among the agricultural activities. Urban centres include Hilton and Howick. Lidgetton is a semi-urban area located in the municipal area (uMngeni IDP, 2023). Howick is the seat of government within the uMngeni Local Municipality. It is located about 30 kilometres from Pietermaritzburg (Kallicharan, 2010, Mudzinganyama, 2012).

With the support of the local government disaster management official of uMngeni, and his superior at the municipality, two events were organised where the municipal volunteers engaged in 'train the trainers model building events.' The first of these events occurred in Howick West, a built-up part of Ward 2. Of the 13 wards, this was where disaster management government officials planned the first opportunity to introduce P3DM. At the Howick West community hall, the local municipal disaster official invited a P3DM 'train the trainers model building event' for municipal volunteers, ward councillors, and NGO representatives. This event, due to the good organisation by the official, started well. The official ensured that the P3DM activities were well introduced. After an introduction, 5 groups of participants (see figures 4-8 A and B) started to build the models.

Figure 4-8 A and B: uMngeni Ward 2 (Howick West) model building workshop

With the expertise developed from the pilot study and the event in Camperdown, it was easier to initiate the event in Howick West. A district official who had attended previous events could again support this introductory workshop. A local official from the uMngeni Municipality started the event at the Howick West community hall. He understood the value of an integrated event, which meant that he included NGO members and ward councillors in his invitations. The official also informed the mayor of the municipality about the P3DM event, as there is a great focus on community partnerships and integrated platforms in this municipality (uMngeni IDP, 2023).

After a clear introduction of the research project, P3DM activities, and the process to be followed, it was easier for participants to become involved in the process. Based on the pilot study, the required materials for three-dimensional modelling were clear. This was confirmed during the first full-study event at Camperdown. As a result, all required materials were in place at Howick West Community Hall. Ward councillors, municipal officials, NGO representatives, and municipal volunteers worked together in 5 teams to develop the models. All models could be developed to the point where the elevation was clear and kitchen, tissues and paint could be added. This meant that the participants understood the three-dimensional model component as desired. A follow-up meeting was requested in which members from the community could add their LIK to these completed models.

In response to this request, a further event was arranged. However, this was not in the same ward with adult community members as desired. The officials expressed their time pressures and

suggested introducing the P3DM model building to volunteers in other municipal wards. Within Ward 4 in the village of Lidgetton, there was a second opportunity to introduce P3DM activities to municipal officials and volunteers. As originally conceptualised to have the 3D-models built in schools by the learners with a follow up LIK adding exercise with adults in workshops would have been preferable.

uMngeni Municipality's Integrated Development Plan for 2023/2024 expresses the desire for better governance through Batho Pele and Operation Sukuma Sakhe. The community hall at Lidgetton is defined as a War Room for integrated service delivery focussing on community participation. The needs and concerns of community members are expressed here, and integrated responses can be developed (uMngeni IDP, 2023). This proved to be an ideal situation for introducing the integrated planning method that P3DM should offer. At this venue, a group of municipal volunteers enthusiastically participated in building three-dimensional models (see figure 4-9 A & B).

Following the same process as after the pilot study and the event in Camperdown, semi-structured interviews with relevant district and local municipal government participants were conducted (see Appendix C). Respondent 1 clarified that the participants properly understood the P3DM activities. This understanding led to "people asking to perform the exercise in their ward." He stated that community members "enjoy the practical experience more than learning theory about disasters."

Figure 4-9 A and B: Lidgetton model building workshop in the Ward 4 War Room

Participants in Lidgetton now had the benefit of several local and district municipal government officials who were familiar with three-dimensional model building. As a result, enthusiastic volunteers (see figures 4-10 A and B) quickly built the models. As in the previous events, the first source of evidence during the P3DM workshops was the observation of participants (Morgan *et al.,* 2017). Field notes were taken during the workshops. Awareness of the key dimensions of observation, as expressed in table 1, was relevant. Initial analysis occurred during the workshops.

Figure 4-10 A and B: The results of the Lidgetton model building workshop during the train the trainer's event

For the event in Howick West, the local official had invited members from the NGO Working on Fire. Members of this NGO expressed an interest in P3DM activities and participated in the interview process after the workshop. Respondent 5 could speak about the standard municipal processes for CBDRA and where P3DM activities could add value. The respondent increased awareness of the UMDM disaster management structures and capacity that was valuable to the study. This could be confirmed in the documentation source of evidence produced by the uMngeni Local Municipality.

When these P3DM introduction events occurred, there was a desire to corroborate the evidence collected. The sources of evidence thus far included multiple documents indicating the minutes of meetings, internal government procedures and capacity assessments, archival records, semi-structured interviews, and observation of participants in multiple workshops. Additional opportunities were sought to provide alternative views and explanations to the responses received from participants at the workshops.

After all the workshops in multiple locations were completed, the private consultants working in the disaster risk management field were contacted again. The consultants were surprised that several

workshops had taken place where P3DM could be introduced. They recognised that P3DM introduction had successfully occurred in difficult circumstances due to capacity problems known at UMDM. The consultants suggested that future projects using P3DM should be introduced in other locations in South Africa.

4.4.Conclusion

P3DM activities enhance the sharing of LIK in disaster management workshops (Banaynal & Dwamena, 2011; Bersalona & Zingapan, 2004). At the outset of the field work, it appeared difficult to introduce P3DM activities to disaster management officials in South Africa. Many obstacles needed to be overcome to enable the sound, comprehensive, and thorough introduction of this novel participatory mapping method to government officials in South Africa. Assessing their perception of the value of P3DM activities to CBDRA required workshops where the officials could assess how these activities might enhance knowledge sharing. The disaster management officials at UMDM, where the case study research took place, were open to the research project. The interest of community members and municipal volunteers who attended varied workshops was clear and encouraging. Participants easily understood the P3DM activities, and the added value of the third dimension was clear to government officials and community members.

5. Analysis and Results

Within the case study observational method, the analysis occurred in an iterative manner while the data were collected during the field work. The research questions inspired the research while within the progressive case study approach a "ground-up" method meant working with data based on field work during the iterative analysis process. This means that the analysis process was initiated during the data collection activities. Observations during field work and preliminary analysis were crucial to this process. Analysis of the single case study in multiple locations required studying the outputs of diverse data collection methods. This chapter focuses on the analysis and results relevant to this dissertation.

Analysing case study data requires an overarching strategy that includes multiple methods of analysis (Yin, 2018). This strategy required examination because the results of the case study analysis influenced the final case study report displayed in this dissertation. Analysis of the case study project allowed the richness of the context of the case to be expressed (Benbasat *et al.,* 1987). The questions proposed at the start of the project defined what needed to be answered in the analysis phase (Yin, 2018), influencing the patterns to be matched and cross-location analysis between the different workshop events.

5.1.Analysis Methods

5.1.1. Pattern matching

Certain assumptions and questions driving the research could be analysed through pattern matching analysis. This was a desirable technique because it facilitated a comparison of predictions and expectations, including rival explanations and the experience based on field work (Kohn, 1997; Almutairi *et al*., 2014; Yin, 2018).

Interest in LIK and the sharing of knowledge types inspired this research project. Based on both international and local literature, an initial assumption (See Section 1.6) was that LIK also existed in UMDM regarding many aspects of community life. This LIK could include knowledge about medicine, religion, the environment, and experience of natural hazards. The second assumption was that community members desired to share that knowledge. To check whether these assumptions were justified during the pilot study, the survey questions incorporated this topic (see Appendix B). These assumptions were also discussed with municipal officials (See Appendix C) during the post-

workshop interviews. Both these assumptions – important when considering the value of participatory three-dimensional modelling (P3DM) activities to be introduced to municipal officials working with community members – were shown to be justified. During the workshop events community members attending stated the range of natural hazards they had experienced, the frequency of these events, and in most cases indicated that they and their families had lived in the area for more than three generations.

Three research questions – question 3, question 5 and question 7 – were analysed through pattern matching, see figure 5-1 and the description that follows the figure.

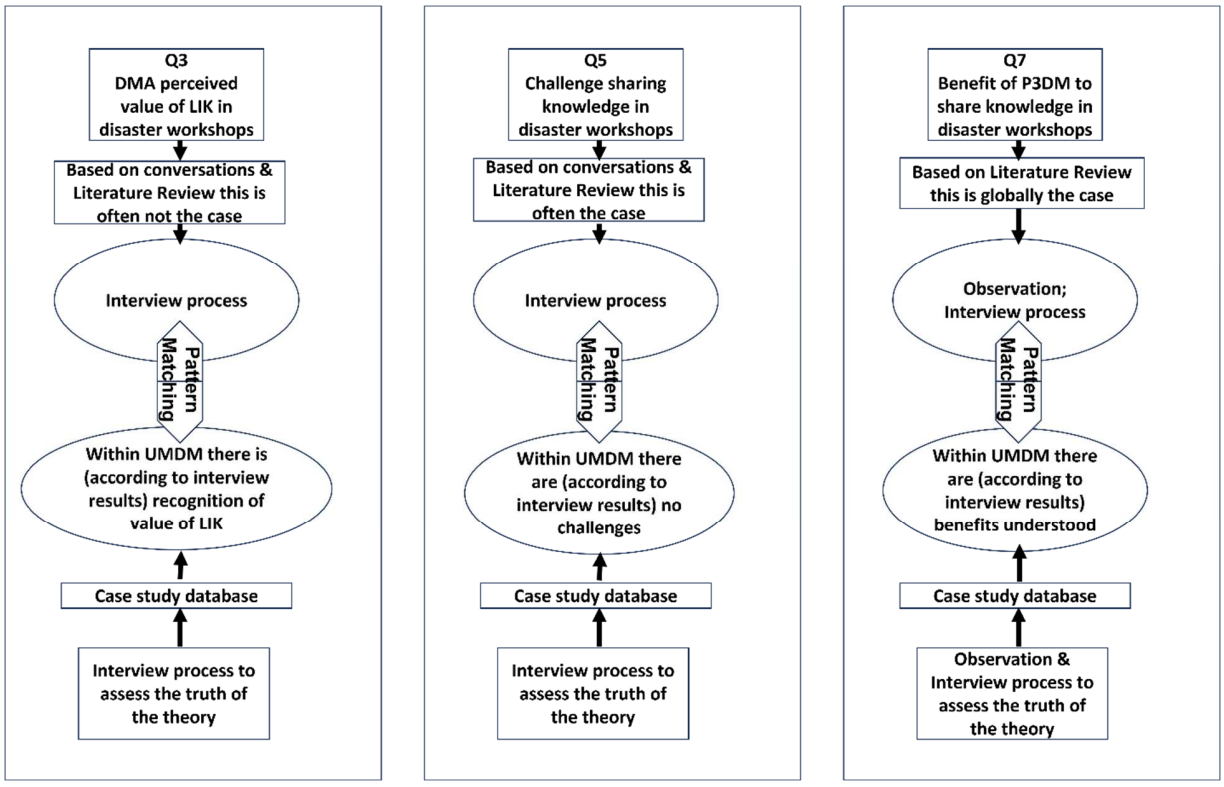

Figure 5-1 (a, b, c) Pattern Matching concerned with Questions 3, 5 & 7 (adapted from Sinkovics, 2018)

Related to Question 3, what was expected when initiating the research project (and backed up by the literature review) was that the NDMF required the inclusion of LIK to enhance CBDRA workshops (see figure 5-1a). The fact that the NDMF clearly stated the advantages of the use of LIK was, according to the literature (Reddy, 2010; Wentink & van Niekerk, 2017), and conversations with private consultants, not also reflected in practise in all South African district municipalities. In terms of pattern matching, the expected response to Question 3 would be that despite the NDMF

incorporation of LIK, this was not practised in South African district municipal disaster management planning. Unexpectedly, the field work – both as observed during the P3DM activities introduced in the field work and the interview results – indicates a different response. In the UMDM, disaster officials recognise the value of LIK and understand that its use in CBDRA workshops is required by legislation.

As a result, there is a clear difference between what was expected, and the result based on field work in UMDM. In response to the (Appendix C) interview questions, UMDM officials stated that due to financial limitations, they have not outsourced their CBDRA. They have become accustomed to locally produced knowledge and methods in which community members take ownership of their planning processes. They facilitated the introduction of P3DM to UMDM CBDRA workshops. If P3DM was introduced in a district where consultants are more involved and LIK is ignored, there may have been greater challenges, although the method could have a bigger impact (see the discussion in Section 6.3).

A pattern expected, leading to Question 5, was that there are currently limitations experienced in sharing LIK during CBDRA workshops in South African municipalities (see figure 5-1b). Therefore, P3DM activities could be introduced to meet the NDMF requirements. A review of the literature, backed up by conversations with private consultants, indicated that this limitation could be expected in the field (Reddy, 2010; van Niekerk *et al.,* 2018). However, in UMDM, the disaster officials claimed that because of the ownership by community members of their planning processes, these limitations are not being experienced. They stated that all attendees of their CBDRA workshops could speak and share their LIK. The lack of matching pattern could be clarified by the atypical situation in UMDM, where CBDRA workshops are organised by the community (see the discussion in Section 6.4).

A further research matter of interest, question 7, that could be responded to from field work concerned the perceived value of P3DM to enhance LIK sharing during CBDRA workshops (see figure 5-1c). The answer to this question could influence future research on the use of P3DM in other districts in South Africa. Regarding this expected pattern, both the assessed observation of participants and interview responses provided positive feedback due to the thorough introduction of the method. This is what was expected based on international experience and the support from government officials at the three levels of government that was developed over the course of a year (see the discussion in Section 6.6).

Disaster risk management officials appreciated and incorporate LIK in their planning and CBDRA events. That UMDM officials allow community members to play a leading role in their events is not common practise in South Africa. This result was unexpected based on conversations with consultants and the literature review. The reason for incorporating LIK was not purely due to appreciation and value of knowledge sharing. A credible rival explanation was learned during the semi-structured interview process. This explanation indicates that finance plays a role in their decision-making regarding the community-driven process. However, lack of financial and human resources is common across South Africa; therefore this explanation may not be the main reason why LIK is well incorporated in UMDM.

During the interview process, UMDM officials stated that, due to the community-driven CBDRA process, there are no limitations currently in sharing knowledge in UMDM. This was again unexpected. A rival explanation for the lack of expected limitation in current CBDRA processes in UMDM regarding sharing knowledge is that members of communities have community structures outside the disaster risk management sphere where knowledge is shared.

5.1.2. Time-series Analysis

The introduction of P3DM activities to officials requires a process lasting more than a year. This time was required to complete the following processes: becoming familiar with the officials and ensuring that the project team was invited to meetings of the officials, developing a method for building a 3D model from locally sourced materials, accommodating the officials in planning workshop events where P3DM activities were introduced, and finally taking the time to discuss the standard processes of officials and question their experiences and views of the value of P3DM.

To analyse the results of the data collected during the workshops, it was necessary to develop familiarity with the disaster risk management officials and the UMDM processes. This is because the fact that the workshops in which P3DM was introduced would be best facilitated by officials. As officials are already known to the communities, P3DM activities would become more accessible to community members if officials introduced them. In order for officials to be introducers, they need to familiarize themselves with the activities, the research team and support the project. This familiarizing process occurred over time. When the project and research team were first introduced, the officials were immediately interested and open to the project. Even then it took almost six months to organize the pilot study (see Section 4.3.1). The next workshop took place at Mkhambathini Local

Municipality for a further five months (see Section 4.3.2). The final two workshops took place a month later in uMngeni Local Municipality (see Section 4.3.3). A shorter period between the last events was due to a better understanding and familiarity with the project value and the P3DM activities. These events were more easily arranged and fully facilitated by the UMDM officials.

At every workshop where P3DM activities were introduced, there was a time period available for participants to understand the activities. These events are time-bound and occur at certain locations. Audio-visual equipment was used to collect data indicating the process in which P3DM activities were introduced to workshop participants. As expected from the international experience (see Section 2.3.1), introducing a new method to workshop participants would be challenging. However, audio-visual equipment could reflect the process over time in which community members and government officials understood the P3DM activities and became involved in contributing their knowledge. On the basis of the international experience, once participants became familiar with the activities—whether model building or adding LIK to the completed model—they fully participated. There were different roles for the participants that the research team and officials could demonstrate and facilitate to induce greater participation.

A further time-based element of the field work was the transfer of knowledge and roles from an outside research team to UMDM officials. Initially, the officials perceived the activities as foreign and outside their standard processes. During the pilot study (Section 4.3.1), an outside research team that had developed the model building process facilitated the four workshops. Due to the UMDM officials' normal role of facilitating disaster risk management planning, valuing the LIK of community members, and quickly understanding the P3DM activities, they made a smooth transition to facilitating an unfamiliar process. The three workshops in Mkhambathin and uMgneni Municipalities were completely facilitated by the officials who took part in the P3DM to enrich their standard CBDRA process.

5.1.3. Cross-Location Analysis

This study involved a single case with workshops in varied locations, indicating that cross-location analysis methods could be applied (Yin, 2018). Therefore, it was possible to compare and contrast the processes, locations, events, and other dimensions that were the focus of this study (Khan & VanWynsberghe, 2008). This analysis becomes a narrative of the cases. Different contexts in different locations assist in developing evidence to support theory (Khan & VanWynsberghe, 2008). Using

Cowie's (2009) list of dimensions, a table was developed to guide the observations that steered the cross-location analysis process, as shown in Table 5-1 and described here.

Data were collected during workshops where municipal disaster management officials could introduce the P3DM model building to disaster officials. These meetings were organised with the support of officials in four different locations. Observations of activities at these locations can be assessed in the context of the research question. Analyses were based on notes taken before, during, and after the events and audio-visual content recorded during the event.

All workshops were organised in community halls within the respective wards. During the pilot study in Impendle, this was the first time that any of the UMDM officials had been introduced to P3DM activities. The follow-up workshops in Camperdown, Howick West, and Lidgetton created more opportunities for officials to grasp the value of P3DM in their planning to reduce the risk of disasters. All these venues were easy to access for community members and had all the infrastructure required to run successful events. Because the venues are locations where disaster officials usually engage with community members, all actors were comfortable at the events. It was possible to observe all relevant participants in the context where they lived.

During the pilot, all the community attendees were aged 25-60 years. During the three follow-up workshops, most participants were young representatives of their respective municipal wards. Municipal officials use young ward representatives to pass learning between members of communities. The only difference in the number of invited participants was at the Howick West workshop. A municipal disaster official invited two ward councillors and two representatives of an NGO active in the area. Variations in actors at the Howick West event had a significant impact on the participants' experience of the event. The variance in participants between workshops was determined by officials and ward committees.

Ward councillors asked questions about the research team and municipal officials rather than purely behaving as participants. They considered the value of the P3DM model building exercise in a neighbouring ward and wondered whether there were alternative applications in their wards where 3D models could add value. The NGO representatives were similarly enthusiastic about the process. Their concern for communicating the dangers of fires in communities could be enhanced through P3DM activities.

Table 5-1 Dimensions of Observation for Cross-Location Analysis (adapted from Cowie, 2009)

Location - Impendle	**Dimensions**
- Nature of the venue and the participants	- eNguga Community Hall where local and district municipal disaster officials, community members 25-60 age group
- Activities performed, materials used, and actions required	- The focus of the workshops was to introduce P3DM model building and adding LIK about natural hazards. Cardboard boxes, paint, glue, toilet paper, and drawing pins
- Events that occurred, and the time taken	- Over four workshops, three sections of a model were built, and LIK about natural hazards was added, taking approximately 10 hours
- Responses of the participants and their goals	- All participants over four sessions understood the model building and LIK added via a legend collectively developed
Location - Camperdown	**Dimensions**
- Nature of the venue and the participants	Camperdown Town Hall in Ward 1 of Mkhambathini. First time including municipal volunteers
- Activities performed, materials used, and actions required	During one event, local and district municipal disaster officials introduced the P3DM
- Events that occurred, and the time taken	- The research team required 3 hours to introduce P3DM to community members and 5 models were built
- Responses of the participants and their goals	- Participants enjoyed the event and understood the value of P3DM
Location: Howick West	**Dimensions**
- Nature of the venue and the participants	- Howick West Community Hall, where two NGO representatives, 2 ward councillors, municipal volunteers and officials attended
- Activities performed, materials used, and actions required	- During one event, the local and district municipal disaster officials introduced P3DM, five parts of a model built
- Events that occurred, and the time taken	- The research team required 3 hours to introduce P3DM to community members and 5 models were built
- Responses of the participants and their goals	- Participants enjoyed the event and understood the value of P3DM
Location: Lidgetton	**Dimensions**
- Nature of the venue and the participants	- Municipal War Room in Lidgetton, Ward 2 of the uMngeni Local Municipality. Municipal volunteers and officials attended.
- Activities performed, materials used, and actions required	- During one event, the local and district municipal disaster officials introduced to P3DM, five parts of a model built
- Events that occurred, and the time taken	- The research team required 3 hours to introduce P3DM to community members and 5 models were built
- Responses of the participants and their goals	- Participants enjoyed the event and understood the value of P3DM

The focus of all the events was P3DM model building activities in preparation for a further workshop where LIK regarding natural hazards could be added to the completed model (as had been evaluated successfully during the pilot). At the multiple events, activities were similar as the reason for the

events was to have the opportunity to introduce P3DM to different municipal officials. Repeating similar processes meant that the research team and certain officials became experienced in facilitating model building. This does not only mean that the process is well developed after occurring at four locations and that it can be repeated by other researchers at other locations in the future. This also means that the usefulness of the study is enhanced through repetition of a similar process.

Regarding objects, at all workshops, the same materials were used to produce all three-dimensional models. An emphasis of the project was to ensure that all materials used were recognisable to participants and easily available. Learning from the literature on P3DM model building materials and the experiences of other projects was significant in planning the workshops in UMDM. This meant that at the workshop events, the actors were divided into groups where each group made a portion of the model. Materials provided included cardboard boxes, kitchen rolls and toilet paper, glue, and containers to decant glue. An expectation ahead of the workshop events – expressed by people living outside the community – was that members of communities would find model building too challenging. Similar to experiences recounted in international project literature, community members in the workshops found that the model building exercise both entertained and educated them.

At the workshop events, the participants spent their time in groups building three-dimensional models. During the pilot events in Impendle, the participants also added representations of their LIK about natural hazards onto the models they had produced. Some participants were guided to use cutting devices and scissors to cut out strips of carboard based on A2 sheets with printed contour lines. Some participants participated in the glueing process. Some participants traced lines over the A2-sized paper with contour lines. The participants learned this process while speaking about their knowledge and experience of natural hazards.

5.2.Study Results

Question 7 calls for an assessment of the enhancement provided by P3DM activities in disaster workshops in South African communities. To answer this question, the field work component of the project was initiated. This question can be assessed through analysis of the data collection that occurred during the field work component.

The UMDM municipal disaster officials encouraged the field work process in which data were collected. The project would not have been possible without their support and collaboration in introducing the new method. Semi-structured interviews shortly after the workshops supplemented the ongoing conversations with officials during the planning and execution of the workshop events. When analysed, there were several results worthy of further discussion, many of which were unexpected when the research was designed.

As per the assumptions underpinning the project, people who are part of families who have lived in an area for several generations have specific knowledge about natural hazards that they wish to share in CBDRA workshops. Based on the literature from international and local research projects (Wisner *et al*., 1995; Maferetlhane, 2012), this was expected. It was good for the progress of this project that within UMDM LIK is valued and incorporated into their disaster risk management planning. The incorporation of LIK in planning and use in CBDRA workshops agrees with the NDMF (COGTA, 2005). Based on existing literature and discussions with disaster risk management consultants, LIK is not always used in South African municipalities (Reddy, 2010). Therefore, it was unexpected for the UMDM disaster officials to incorporate LIK into CBDRA (see discussion Section 6.1).

The project required organised events in which practitioners would observe community members building models and sharing knowledge. The officials needed to see that P3DM activities enrich the communication of LIK about natural hazards by communities and their responses to hazardous events. There was a risk that participants at the workshops would not grasp the concepts required quickly. Then, officials might lose interest in the project as the added value of P3DM activities becomes less clear. However, community members quickly understood how to build models in their assigned groups. Therefore, workshop participants, when they understood what was desired, could quickly learn the new 3D model building process. UMDM officials already incorporate mapping in their CBDRA workshops. As a result of conversations with officials in preparation for the workshops this was confirmed during the interview process. This meant that community members did not require the mental mapping process (described as used in international P3DM projects and in Section 4.3.1 as used in the UMDM field work) used as part of the P3DM activity introduction.

After a brief time and with good support from the officials, the community members' initial hesitation to participate was overcome. Respondent 1, an official at uMngeni Municipality stated that once participants became involved, they found the activity fun and easy to be involved in. With good

facilitation, community members together with municipal officials could speak of a legend of the elements required for the new 3D model. Based on that legend LIK about hazardous events experienced in the community were clearly added to the model. Drawing from the municipal officials' experience in regularly arranging CBDRA workshops, the P3DM workshop events were successfully organised and well facilitated.

Understanding the standard CBDRA processes at UMDM is needed when P3DM activities are introduced to enrich the standard processes. It was tempting to arrange events outside the municipal structures. When designing the field work component of the project, the option to set up tents and invite community members to participate in model building and learning how to add LIK to those models was considered. As an outsider, the standard process can appear too time-consuming, and following the municipal processes appeared to delay the project too much. When analysing the interview process results, there is no doubt that attempting to create workshops outside the municipal processes would have been disastrous for the project. The UMDM officials would have distanced themselves from the project and viewed it as competing with their CBDRA processes. This meant that an adaptation of standard process of the international introduction of P3DM (Kusratmoko *et al*., 2017) was required (see Section 6.2).

Learning about the standard CBDRA processes at UMDM and legislative requirements meant that municipal volunteers were incorporated into the project. Volunteers assist in bringing other community members into municipal processes. As the task involved introducing P3DM using municipal structures, it was sensible to employ municipal volunteers. During the interview process the disaster officials mentioned that the volunteers were used to cascade information and methods to other community members in their wards. During the workshops, any initial hesitation about model building was overcome through the volunteers' youth and enthusiasm for the creative exercise.

When introducing P3DM activities to enrich the communication of LIK, it was interesting to consider what the added value is perceived to be. Finding the value added was considered to be an important motivation for implementing this novel method as part of standard practice. The value perceived by the officials who attended the P3DM activities could influence the future use of P3DM. Consistently, the results of the interviews clarified that officials recognise the education and training value of P3DM. The education and training required by South African legislation can be complied with using P3DM activities. Education is already a focus of officials at UMDM. They visit schools in their areas of

responsibility and could incorporate model building as an exercise in those schools. A collaborative 3D model building process was understood to be another advantage of the P3DM activities. The participatory element of P3DM activities is discussed in Section 6.3. Participation was the greater focus of the project than concern for the quality of the data that would be produced. Data quality was not a concern expressed by any official involved in the project, see the discussion in Section 6.4.

While UMDM officials already recognised the value of LIK and incorporated it in their CBDRA workshops, they were interested in the addition of elevation to their standard practise of using mapping in their workshops. Results from the interviews and discussions during the workshops indicated that the officials and NGO representatives understood the added value of elevation to sharing knowledge about disasters in the community. The impact of elevation is experienced by community members as they relate to their locations in terms of elevation and the model better reflects their lived reality. Elevation impacts certain hazardous events. The LIK of the community in Impendle had already influenced the location of lightning conductors in areas of high elevation. Within the 3D model, participants noted valleys and mountains in their context and the impact of hazards on their livelihoods.

All officials who responded to the interview questions stated that it would be possible for a local government disaster official to implement P3DM into their standard processes. This is an important question that may be answered differently in different municipalities in South Africa. At UMDM, the officials at the local level take ownership of their planning processes to reduce the risk of disaster. There are several challenges for them to deal with. This discussion point was deliberated with officials during the workshops, post-workshop interviews, and conversations with private consultants after the field work was completed. The challenges of implementing P3DM at the local municipal level are assessed in Section 6.5.

5.3.Conclusion

This chapter discusses how the analysis methods were employed in this study to assess the data collected when introducing P3DM to UMDM disaster risk management officials in the field work described in Chapter 4. The results of the analysis indicated that UMDM officials consider that P3DM activities enrich knowledge sharing required by legislation during CBDRA workshops. The desire to use municipal structures and processes when introducing P3DM was justified because it allowed the

transfer of responsibilities from the research team to UMDM officials. In Chapter 6, the focus is on the discussion based on the analysis and results.

6. Discussion

Participatory three-dimensional modelling (P3DM) activities can provide a fresh method to incorporate local and indigenous knowledge (LIK) when planning to reduce the risk of natural hazards becoming disasters. A more comprehensive assessment of the challenges of P3DM implementation in South African municipalities is required. A comparison is made between the introduction of P3DM in South Africa and international introductions of P3DM based on the literature. This chapter discusses topics based on the results of the study. Other considerations developed from this research are also reflected in this chapter.

6.1.Impact of Case Choice – UMDM vs. other South African Districts

After introducing P3DM to UMDM officials, it is important to consider whether the same process could be followed in other South African districts. As mentioned in Section 4.2, the CBDRA approach used in UMDM may not be typical of other South African districts. Even an atypical case could add value if this means that the unusual aspects could be identified. It is then possible to suggest which conditions are optimal for the introduction of P3DM in South Africa (Crowe *et al*., 2011).

Knowing that within UMDM there was an acceptance of LIK and its use within their community workshops it was relevant to initiate the project in this location (as discussed in Section 3.2). When choosing a case without prior knowledge of the research context or about existing organisational structures, there was a chance that the choice of case in UMDM was atypical in South Africa. On the basis of conversations with private consultants in the DRR field, it was clear that this openness to using LIK in CBDRA and community-driven processes is not necessarily typical practise in South Africa.

6.2.Introducing P3DM Activities Internationally vs. South African Reality

International experiences are recounted in the literature review (see Section 2.3). In this section international best practise to introduce P3DM activities have been described based on manuals produced by experienced researchers (Rambaldi & Callosa-Tarr, 2002; Rambaldi, 2010; Gaillard & Cadag, 2013; Dovarch, 2017). It is relevant to compare and contrast the process recounted by many researchers working on projects around the world with the experience of the research in UMDM in South Africa.

It is always challenging to introduce new methods to an organisational structure that uses established practises (Leonard-Barton & Kaus, 1985; Mirvis *et al*., 1991). Successful implementation of a new method requires a coherent strategy (Mirvis *et al*., 1991). A coherent strategy using existing disaster municipal structures was considered essential to increase the chance of success in introducing and implementing P3DM activities to enable relevant disaster officials to perceive the benefits of P3DM. As a result, the case study reported in this dissertation used the existing disaster management structures. A desire to employ best practise for introducing the new method was recognised. This necessitated the correct timing relevant to a particular need and population. Acceptance from the management of the organisation was necessary (Tulenheimo, 2015). This study aimed to show that P3DM could become a part of South African CBDRA practise to enhance LIK use without requiring external support. Using municipal structures and gaining buy-in over a period meant that several officials understood the enhancement provided by the P3DM.

Consequently, the research project dedicated to P3DM activities was initially introduced to a wide group of disaster officials at three levels of government concerned with planning for natural hazards in UMDM. This process of introducing the concept of P3DM activities to various officials at the district and local municipal levels within UMDM took more than a year. Engagement occurred before initiating the pilot study component of the research. In terms of the progressive case study approach, it was important to carefully select the first location where the pilot study occurred. The success of the event at this location opened the opportunity for later workshops at other locations. After the pilot study, there were more introduction sessions about the new method using P3DM activities. Ongoing conversations with disaster officials at the district and local municipal levels are required to keep all governmental stakeholders engaged in the project. Every opportunity to introduce the new method to non-governmental organisations collaborating with UMDM officials was used.

Within UMDM, disaster officials often meet community members in workshops to improve their understanding of the risk of hazard and use LIK which is understood to be valuable. Buy-in from local municipal gatekeepers who know the needs of the communities was required, as was a UCT ethics requirement (Section 1.5). The importance of every opportunity to engage officials to boost their support for the project was clear. Support from district-level officials would also be required. The support of local municipal disaster practitioners was needed. Standard municipal processes were used to introduce the project to multiple communities. Snowball sampling to gain research participants was a critical component of this study. Owing to a lack of familiarity with the disaster

practitioner field and not being an associate of the UMDM disaster practitioners, this was challenging. The challenge was overcome through ongoing meetings and consistent description of the added value of P3DM. Ensuring that officials were not threatened by the novel method was important.

6.3.P3DM Enhances Participation in CBDRA

The enhancement of knowledge sharing among participants is relevant to this research. For this project, encouraging community participation during various participatory disaster workshop activities is of greater importance than the quality of spatial data that results from the community disaster engagement sessions or future use of the three-dimensional mapping produced.

Participatory GIS practises seek to expressly increase the participation of marginalised members of a community (Abbot *et al*., 1998; Dunn, 2007; DeGraff & Ramlal, 2015); this is also a challenge for P3DM implementation (Best *et al.*, 2021; Hayashi *et al*., 2021) in disaster planning (Banaynal & Dwamena, 2011). The history of projects involving the implementation of P3DM shows, since the 1980s in Vietnam and later further developed in the Philippines, the aim to enhance public participation in planning processes (Rambaldi & Van Lanh, 2003; Hayashi *et al.,* 2021). It was noted with pleasure that community engagement is clearly a standard practise for disaster officials within the UMDM family of municipalities. The standard practise of disaster engagement creates a good environment, once the workshop is organised, to introduce and implement a novel method for knowledge sharing. It is especially challenging to achieve higher levels of participation when introducing new methods.

6.4.Assessment of the Data Quality of P3DM Activities

P3DM activities are impacted by the same concerns about data quality as other PGIS exercises (Brown, 2012; Musungu, 2015; Brown *et al*., 2017). Researchers who work in the PGIS field in their reporting speak of several aspects of concerns about data quality. PGIS, while aiming to improve participation and access, could sacrifice quality and cartographic precision (Ramirez-Gomez *et al.,* 2017). During a conference of PGIS researchers, a research interest expressed involved the information provided by participants regarding accuracy (Brown & Kytta,2018). The accuracy of LIK is typically compared with that of SK; however, this may not always be the correct method (Brook & McLachlan, 2005). Accuracy in PGIS does not always need to be precise. At times, precision can be counterproductive if it creates false impressions of mapping precision that contains ambiguous and fuzzy spatial concepts (McCall, 2006; DeGraff & Ramlal, 2015).

6.5.Challenges in Implementing P3DM in UMDM

There are challenges in implementing the freshly introduced P3DM method into an organisation such as UMDM. P3DM activities are always altered to suit local conditions (Guillemette *et al*., 2017). In South Africa, unique challenges have been experienced. Even though disaster practitioners at the district and municipal government level in UMDM expressed general interest when P3DM was introduced, it was challenging to implement the project. Due to the P3DM activities being new to all practitioners, there were many meetings required that took more than a year before the project could be implemented.

Local government disaster officials already had schedules of community engagements planned for the year or quarter ahead. Integration of several sessions with one community caused challenges to the practitioners' planning due to their standard processes (as detailed in section 4.2). P3DM, as it is used internationally, would be too time consuming to be incorporated in the schedules of the UMDM officials. P3DM aims for all officials, community members, and NGO representatives to be involved in the process. This is a challenging concept, not actually difficult to organise, but (while required by legislation) is not normal practise in UMDM.

6.6.Conclusion

There is potential future use of P3DM in South African disaster planning workshops to enhance the inclusion of LIK. This is clear after an exercise in UMDM, as described in this report of fieldwork-based research work. International P3DM projects have inspired the study and the desire to introduce P3DM activities in South Africa, where officials use CBDRA to reduce the risk of disaster in their municipalities. International practise in P3DM may differ from the standard process in UMDM, as described in Section 4.2 of this dissertation. The introduction of P3DM activities to allow disaster practitioners to assess the value of these activities was challenging. The implementation of P3DM activities by UMDM officials was expected to face challenges. When using P3DM, there is an interest in enhancing participation in workshops, especially among marginalised groups (Kusratmoko *et al*., 2017; Johnson *et al*., 2022). The quality of data collected in workshops can also be a concern. Based on these topics, an assessment regarding the future use of P3DM is relevant. The implications for both PGIS and disaster planning disciplines in South Africa are described in this chapter.

7. Conclusions and Recommendations

Participatory three-dimensional modelling (P3DM) activities were introduced to government officials and private consultants working in the disaster risk management field in South Africa. It was understood based on literature (van Riet, 2009; Reddy, 2010; van Riet & van Niekerk, 2012) and conversations with private consultants that CBDRA application in some South African municipalities has limitations in following the requirements of the NDMF relating to community participation and integration of LIK to bridge knowledge types. Introducing P3DM activities could prove valuable to disaster management officials attempting to comply with NDMF requirements. Through this research project, relevant disaster officials and private disaster consultants were introduced to P3DM activities, allowing them to assess whether to incorporating P3DM activities in their future disaster planning processes would be possible and desirable.

Participants at the UMDM P3DM workshops confirmed that P3DM activities (as described in Section 4.3) could enrich the current practise of CBDRA in UMDM (as described in Section 4.2). The observations made during workshops and the results of the post-workshop interviews validated this usefulness. P3DM could be a means to promote disaster risk management by incorporating LIK in UMDM in line with South African disaster risk management requirements.

7.1. Reflections on Research Aims, Objectives, and Questions

The aim of this research was **to investigate the perceived benefit of introducing P3DM in uMgungundlovu District Municipality during CBDRA workshops to improve knowledge sharing as required by South African disaster risk management legislation.**

The stated aim of the research (see Section 1.2) was to investigate whether introducing P3DM would enrich the use of LIK sharing during CBDRA workshops. Investigations occurred through a series of workshops in the field within UMDM. The field work, starting with a pilot study, was well-supported by relevant disaster risk management officials. This project was initiated based on assumptions of existing LIK in the community and the desire to share LIK with other stakeholders in disaster risk management. Based on international and local literature and conversations with private consultants, there were expectations of limitations in applying disaster risk management legislation requiring the use and incorporation of LIK in planning.

Within UMDM, as examined during the field work observation process and confirmed by the officials, LIK is already incorporated as is legislated in disaster risk management planning. This appreciation of the value of LIK made introducing P3DM activities easier. Officials were interested in a new method and members of communities within UMDM had experience of being consulted for their knowledge and enjoyed the practical exercises involved in P3DM. As a result, the aim of the research was more easily attained than expected due to the openness and interest of the officials and other relevant stakeholders to a new method that enriched the participatory element of the standard CBDRA processes.

The aim of this research was supported by several research objectives and questions. Objectives guided the research process effectively. Research questions could be translated into the methods used throughout the research and drove the examination of varied aspects relevant to the project. The questions also influenced questions discussed with disaster risk management stakeholders during the P3DM activities and after the workshop events during the interview process. These objectives and questions are briefly discussed and assessed in the following paragraphs.

Objective A incorporated Research questions 1 to 3, which assessed an understanding of the perceived benefits of knowledge sharing during disaster workshops. Within international research into reducing the risk of disaster and the impact of communities, international disaster management agreements, and local South African legislation, there is an understanding of the significance of using the knowledge of people in the communities where they live. That the value of LIK is clear in all of these spheres, as can be shown in an assessment of the research questions that are part of Objective A.

7.1.1. Research question 1: perceived benefits of sharing LIK about disasters among stakeholders

This has been discussed in Section 2.2.1. The conclusion, when assessing question 1 about the perceived benefits of sharing knowledge, was that the benefits include sharing of broader sources of knowledge. Community resilience can be enhanced as members of the community communicate about their experience and responses to disasters and provide support to each other. It ensures that community members do not become apathetic as their knowledge is relevant to government services and planning. There can be gaps in knowledge when relying only on SK (Wheeler & Root-Bernstein, 2020). An appreciation and understanding of the value of LIK could encourage the participation of

communities in planning for their area (Dekens, 2007). The promise of knowledge integration is greater community resilience (Bohensky & Maru, 2011).

7.1.2. Research question 2 assessed the perceived benefits in international agreements of sharing LIK about disasters

This has been discussed in Section 2.3.1. International agreements that speak to the benefits of sharing knowledge to reduce the risk of disaster include the Sendai Framework, the Paris Agreement and the Sustainable Development Goals. These agreements recognise the value and contribution of local knowledge while still emphasising technological measures.

7.1.3. Research question 3 questioned the perceived benefits of sharing LIK about disasters in South African disaster risk management legislation

This has been discussed in Section 2.3. Legislative support exists for the use of LIK and sharing knowledge. It is recognised as part of responsible governance to include the communities considered at the coal face of the impact of hazardous events. Better planning that is inclusive of the knowledge of people who have lived in an area for several generations is recognised.

Objective B included Research questions 4 and 5, which required an understanding of the current limitations of knowledge sharing during disaster workshops. As with the previous objective, here both international and local South African literature and experience were assessed to better understand this objective. The international and local literature suggests that there are specific challenges in sharing knowledge about disasters. The experience of UMDM during the field work component of the study was contrary to the expectation developed from an assessment of the literature.

7.1.4. Research question 4 identifies the challenges recognised in international research literature concerning sharing LIK about disasters

This has been discussed in Section 2.2.2. An awareness of power relations within a community can result in greater challenges in sharing knowledge of certain community members. Knowledge gatekeepers of the community can impact the openness for sharing knowledge. Not all community members have expertise on all topics relevant to disaster risk management planning. These challenges require thorough understanding of the community which takes a longer period of time, as

is normal in international examples of P3DM implementation. An understanding of these challenges influenced the desire to introduce P3DM through standard CBDRA processes at UMDM.

7.1.5. Research question 5 considered the challenges in South Africa of sharing LIK about disasters in community workshops

This was discussed in Section 2.3.2 and considered in the case study narrative Section 4.2. Based on the challenges in knowledge sharing in communities recognized in international research literature there was an expectation that this could also be expected in South Africa. South African literature and conversations with private consultants working in the disaster risk management field confirmed the challenging environment for knowledge sharing experienced internationally. However, during the field work in UMDM officials in semi-structured interviews stated that in their standard processes for CBDRA these challenges don't occur. Observation of participants during the P3DM activities in workshops in UMDM suggested that community members in this district easily communicate and share their LIK regarding natural hazards.

International literature recounting the challenges of sharing knowledge included knowledge gatekeepers and their impact. Not all members of a community can be expected to have complete knowledge relevant to communicating about disasters. A thorough knowledge is required of a community when planning for disasters. These challenges are reflected in South African challenges when sharing knowledge about disasters in community workshops. In addition, local disaster legislation is not perfectly reflected in practise. The legislated structures are not consistently in place across South African municipalities (Wentink & van Niekerk, 2017). The optimal engagement with communities is not always occurring (Reddy, 2010). As a result, stakeholder engagement is a piecemeal process. What is a challenge is a locally-driven process that municipal officials can drive with their communities rather than outsource to consultants (Wentink & van Niekerk, 2017).

Objective C incorporated Research questions 6 and 7, assessing the perceived benefits of P3DM for community workshops. This assessment was through a literature review of international P3DM projects and case study field work. As the final objective of the project this was the focus of the research. After the previous objectives had guided the research process through an understanding of the disaster risk management context both internationally and locally focussing on expectations of current limitations in sharing knowledge about disasters the final objective sought a solution for this challenge.

7.1.6. Research question 6 considered the ways internationally P3DM is perceived to benefit the sharing of LIK about disasters

This was discussed in Section 2.5.2. P3DM literature speaks clearly about the advantages of using this method to enrich the sharing of knowledge. Community ownership of disaster risk management planning occurs through community driven design, data collection and analyzing of LIK through the P3DM activities. Community empowerment and increased participation is reflected in the literature. The knowledge can be shared with stakeholders within and outside the community.

7.1.7. Research question 7 assessed the perceived benefits of P3DM activities for LIK about disasters in South Africa

This was discussed in Section 5.2. It became clear in the responses to interview questions that the positive (without divergent views) stance of the officials was due to their openness to learning new techniques to improve good governance and participatory planning. The inherent Batho Pele and Operation Sukuma Sakhe principles encourage the desire for greater accountability to community members and the involvement of communities in disaster planning using LIK. This assisted in introducing P3DM at UMDM. Community members were excited to be involved in the project because they saw the exercise as a fun, practical activity that emphasised their LIK. After the usual initial hesitation in activities new to them, participants in the workshops could perceive the benefits of P3DM activities.

7.2.Recommendations and further research opportunities

Section 6.1 examines whether the introduction of P3DM activities in a different municipality in South Africa would be as welcome as was the case in UMDM. Further research on this topic in South Africa could test whether this expectation matches reality. Expectations regarding scepticism by those using SK in including LIK in disaster planning that is based on international and local literature could be dated. It is possible that private consultants working in this field have experience that is not consistent with the experience of other districts. A regular assessment regarding the use of LIK as required by South African disaster risk management legislation across the country would be valuable. How P3DM activities would be differently received in a district where LIK is not being incorporated in CBDRA as desired by NDMF could be an opportunity for further research.

The original project design included children from various schools in different municipalities building three-dimensional models. The model building exercise in schools would introduce the

project to the wider community. After building models, the adults of the community, during standard CBDRA workshops arranged and facilitated by municipal officials, would add their LIK to the model built by the children. Due to understandable ethical concerns regarding using Education Department facilities and the anticipation that the required permissions would delay the study, this element involving school children was removed from the design. In hindsight, model building by children would have added immense value to the project and more effectively introduced P3DM to the communities. Future research making use of P3DM activities should revisit the aspect of including schools within an educational component of a project that introduces the project to the community where adults could add their LIK to the completed models. This would further enrich compliance with disaster risk management legislation in a South African district municipality.

International P3DM best practice includes export of 3D models completed during fieldwork disaster risk management workshops (Rambaldi, 2006; Rambaldi, 2010; Gaillard & Cadag, 2013). The exported digital 3D models are georeferenced and integrated with existing spatial data in online GIS models. This process is not required in response to any research objectives or questions that drove this research project. However, this would add value to the process of sharing the valuable knowledge exchange process with disaster planning in support of the community for the future use of P3DM. Due to the georeferenced mapping that is generated, the scientific quality of the data would be increased by joining the existing SK in the municipal GIS system.

7.3.Research Findings

P3DM was successfully introduced at UMDM in South Africa. After the encouragement and openness of the UMDM disaster risk management officials it was possible to use case study methodology at multiple locations. Data was collected during and after workshops arranged by the officials in their municipal areas. Participants at the workshop events were observed, documentation about disasters in the workshop locations was collected and participants were asked questions during a semi-structured interview process. The collected data was analysed during and after the workshop events. Results included that the assumptions about LIK of people in their communities concerning natural hazards were justified. The openness of officials in UMDM to being introduced to P3DM was a surprising result. This was different to international experience and not expected based on South African literature and the expectation of disaster management consultants. An initial hesitation (similar to international experience) was easily overcome by workshop participants where P3DM is introduced.

As the officials become more familiar with P3DM they took ownership of the introduction process. The model that is built collaboratively that now adds elevation better reflects the lived experiences of participants of disaster workshops. This made P3DM an attractive option for the disaster management officials who attended the P3DM introduction workshop events. While it is clear that local government officials could implement the use of P3DM, though this would present several challenges that would need to be overcome. If P3DM were to be used for disaster management community workshops the collaborative and participative elements required by South African disaster management legislation would be enhanced. Knowledge types concerned with natural hazards would be better bridged and the benefits perceived by participants in CBDRA workshops at uMgungundlovu District Municipality would become better known.

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APPENDIX A: RESEARCH CONSENT LETTER

Researcher: Rut Wielenga
Contact: rutger.wielenga@rhdhv.com, 072 496 7527

Title: **Bridging Local and External Knowledge for Disaster Risk Reduction Planning in South Africa: the value of Participatory 3D Modelling**

Supervisor: Simon Hull
Contact: simon.hull@uct.ac.za

Dear Participant,

My name is Rut Wielenga. I am a Master thesis student at the University of Cape Town. I kindly request your participation in a Master research project that I'm conducting titled: Bridging Local and External Knowledge for Disaster Risk Reduction Planning in South Africa: the value of Participatory 3D Modelling. The intention is to ascertain the perception of participants attending disaster risk reduction workshops.

- The use of all information is in terms of the ethics policy of the University of Cape Town.
- No information will be published which will lead to your detriment.
- All information is used for research purposes only and the lead researcher is a student at the University of Cape Town.
- You may withdraw from the research at any stage.

Your participation in the research will greatly benefit my study but will not benefit you financially or provide benefit to you in terms of access to government officials or disaster risk reduction planning, though I hope that it would benefit awareness of location and local issues and communicate this to relevant officials.

Thank you for your time and participation.
Sincerely,
Rut Wielenga, M Phil(Geomatics) student, University of Cape Town

APPENDIX B: SEMI-STRUCTURED INTERVIEW GUIDE FOR COMMUNITY MEMBERS

The following questions are aimed at adults living in the community where the workshop is planned to take place. No children will be interviewed. For government officials and consultant disaster risk practitioners there will be different interview questions.

Question 1:

The aim of this set of questions is to understand the involvement and integration of the participant in the community to gauge potential extent of local knowledge.

1.1 What is the name of the community where you live?

1.2 How long have you been living in this community? Do you stay in the community all the time?

1.3 For how many generations has your family lived here?

Question 2:

The aim of this set of questions is concerned with a local understanding of disasters and the reduction of risk of disasters and capacity to endure the results and learning about disaster.

2.1 Please indicate (circle) which disasters have been experienced in your community?
Floods, Drought, Earthquake, Fire, Strong Wind, Lightning, Tornado, Other Types (State other type).

2.2 How often do those types of disasters take place? Every month, every year, once in 2 years?

2.3 At what time of year do the disasters take place?

Question 3:

The aim of this set of questions is to gain an understanding of the demographics of the respondent. It has been found in other research that gender, educational achievement, and religious beliefs influence understanding of and response to disaster.

3.1 Please indicate (circle) the Gender of the respondent

Male/ Female/ Other / Choose Not to Say

3.2 Please indicate (circle) Age group of the respondent

Below 18 18 to 25 25 to 60 Over 60

3.3 Highest Education Level attained by the respondent

Primary Secondary Tertiary

APPENDIX C: SEMI-STRUCTURED INTERVIEW GUIDE FOR GOVERNMENT OFFICIALS

These following questions are aimed at external actors (government officials, disaster risk practitioner consultants, academics, etc.)

Question 1:

The aim of this set of questions is to gauge and understand the participant's understanding of the value and use of local and indigenous knowledge (LIK).

Please indicate (circle) what type of local and indigenous knowledge you expect community members to have about their community that they may want to share with you.

Agriculture, Medicine/ Health care, Environmental conservation, Experience of disaster, Education, Spiritual, Other Types (State other types).

1.1 Please indicate (circle) which element(s) of local and indigenous knowledge (LIK) you consider to be important (you may choose more than one).

- LIK provides ways to solve problems
- LIK is well-respected by community members,
- LIK provides an important contribution to international development knowledge,
- LIK are in danger of becoming extinct and require preservation and record,
- LIK is an under-utilised resource for disaster planning,
- LIK is relevant for disaster planning

1.2 Please indicate (circle) how you think people currently share their local and indigenous knowledge (LIK) within a community.

Oral/ Word of mouth, Storytelling, Community meetings, Ward committee meetings, School meetings, Common practises, Other Types (state other type).

1.3 What is your opinion about the effectiveness of these methods to share local and indigenous knowledge within the community?

_____

Question 2:

The aim of this set of questions is concerned with an understanding of community experience of natural hazards, the use of LIK for disaster planning and perception of value of LIK for disasters in DMA.

2.1 Please indicate (circle) which natural hazards you understand to have been experienced by people in this community.
Floods, Drought, Earthquake, Fire, Strong Wind, Lightning, Tornado, Other Types (state other type).

2.2 Please indicate (circle) the methods community members learn to respond to a natural hazard.
Community meetings, Common practises, Other Types (state other type).

2.3 Please indicate (circle) what resources do you think community members draw on to be resilient when natural hazards occur.
Strong family links, Mutual assistance, Other Types (state other type).

2.4 What is your understanding of current legislation (DMA) regarding the value of including communities and their local and indigenous knowledge (LIK) in planning for natural hazard?

_____

_____

_____

Question 3:

The aim of this set of questions concerns current community engagement methods – the practise of DMA community-based assessments and community engagements for disaster awareness.

3.1 Please describe current methods of engagement with communities about disasters.

3.2 How effective are the current methods to engage members of communities for disaster awareness and disaster planning? (Please circle one)

Ineffective Slightly effective Moderately effective Highly effective

3.3 What methods are currently used to include local and indigenous knowledge in planning for disasters?

3.4 What are some reasons that currently limit communicating about local and indigenous knowledge (LIK) during these engagement sessions?

3.5 What is currently the purpose of community engagement about disasters?

Question 4:

The aim of this set of questions is concerned with the perception of the value of P3DM activities to share local and indigenous knowledge (LIK) about disasters between community members and officials for disaster planning.

4.1 Do you think participants of the P3DM activities – model building and workshop – understood what they were doing? What reason do you have to think this?

_____

4.2 In what ways did you see participants become involved with creating the 3D model?

_____

4.3 Do you think there were parts of the workshop that were difficult to understand for participants? Why was this? How could this be improved?

_____

4.4 Based on your experience of P3DM activities, in terms of the Disaster Management Act (57 of 2002), please indicate (circle) what **Supportive Enablers** would be the best to connect future use of P3DM activities in South Africa?

a) Information management & communication,

b) Education, training, public awareness &research,

c) Funding arrangements for disaster risk management.

4.5 In what ways did you see participants overcoming any initial hesitation regarding adding content to the 3D model?

_____

4.6 In what way is this 3D model useful for the municipality to understand community members' experience of disaster?

_____

4.7 What problems do you see in using the 3D model in speaking about local and indigenous knowledge (LIK) about disasters?

_____

4.8 In terms of the Disaster Management Act (57 of 2002), please indicate (circle) what **Key Performance Area** would be the most relevant for future use of P3DM activities in South Africa?

a) Institutional arrangements,

b) Disaster Risk Assessment,

c) Disaster Risk Reduction,

d) Response & Recovery.

4.7 How could the model building and adding local and indigenous knowledge (LIK) be incorporated into the disaster programme of the municipality?

_____

APPENDIX D: RESEARCH ETHICS APPROVAL DOCUMENT

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA · UNIVERSITEIT VAN KAAPSTAD

2022/09/15

EBE/00010/2022

RE: Research Ethics Committee Project Approval Letter

Dear Rutger Wielenga,

Your application for ethics review of your project titled

Bridging Local and External Knowledge for Disaster Risk Reduction Planning in South Africa: the perceived value of Participatory 3D Modelling

has been reviewed and evaluated by the

Engineering & Built Environment Committee.

You may proceed with your research project titled:

Bridging Local and External Knowledge for Disaster Risk Reduction Planning in South Africa: the perceived value of Participatory 3D Modelling

Please note that should:

(i) any serious or adverse effects to participants occur and/or,

(ii) aspect(s) of your current project change and/or

(iii) any unforeseen events that might affect continued ethical acceptability of the project occur then you should immediately report this to the approving REC. You may be required to submit an amendment to this application, in order to determine whether the changed aspects increase the ethical risks of your project.

Based on the information supplied your application has been successful and is approved.

Please note the following additional conditions associated with this approval:

(i)

Regards,

Engineering & Built Environment Committee.