Disaster risk due to fracking in the fragile ecosystems of the Nama Karoo: A Disaster Risk Management Perspective

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SUMMARY

The South African Disaster Management Framework (SA NDMF) and South African Disaster Management Act 57 of 2002 (DMA), serves as a guideline which all spheres of government in South Africa needs to integrate to enable coordinated disaster risk management at all levels of government. The focus of the SA NDMF and DMA is to prevent or reduce disaster risk and disaster severity in South Africa. Hydraulic fracturing or fracking is considered to be a high risk mining process, which is proposed for South Africa. The Nama Karoo region in South Africa is set apart for fracking. The need to address the possibility that fracking could be coupled with an increase in disaster risks for the Nama Karoo area needs to be addressed. Further risks associated with fracking is coupled with the lack of information concerning the processes used during fracking, lack of knowledge concerning use of chemicals during the fracking process, and fracking companies disclosing selective hazardous chemicals used during the fracking process.

This study focused on interviewing organised community groups and local disaster management government officials from selected towns in the Nama Karoo of South Africa. The towns selected for the purpose of this study include Beaufort West, Britstown, Carnarvon, Colesberg, Graaff Reinet and Victoria West. These towns were specifically chosen since they fall in the Nama Karoo area proposed for fracking. The interviews reflect on perspectives from both organised community groups and local government, concerning what fracking companies have communicated with communities in the designated fracking area. The interviews also indicate general fracking knowledge, local water and environment management knowledge, and knowledge concerning disaster management at a local level.

The results of the study concluded that all communities interviewed for the purpose of this study, were not equally informed with regard to fracking and fracking practices. The organised community groups and local government responses to the research questions varied from ‘well informed’, to ‘no knowledge at all’ concerning fracking. The organised community groups, furthermore, indicated that they were not aware of any legislation in place to enable disaster management and various local governments also indicated that they were lacking in capacity to enforce the relevant legislation for their areas, even before fracking commences.

Considering these vast differences in knowledge distribution and that fracking companies do not disclose all their processes and process requirements, which is in conflict with the aims and objectives of the SA NDMF and DMA, it stands to reason that recommendations need to be made to address these issues. This study recommends that DMAF structures and communication structures should be established, allowing even distribution of fracking related knowledge throughout the Nama Karoo.

Keywords:

Fracking; hydraulic fracturing; groundwater; environment; pollution; South African Disaster Management Act 57 of 2002 (DMA); South African Disaster Management Framework (SA NDMF); Nama Karoo; disaster risk management; risk management; disaster risk reduction; key performance area (KPA); enabler.

OPSOMMING

Die Suid-Afrikaanse Rampbestuursraamwerk en die Wet op Rampbestuur (57/2002), dien as ’n riglyn wat deer elke regeringsfeer in Suid-Afrika geïntegreer moet word sodat ramprisikobestuur op alle regeringsvlakke gekoördineer kan word. Die Rampbestuursraamwerk en die Wet op Rampbestuur, fokus daarop om die risiko en felheid van ramprisiko in Suid-Afrika te voorkom of te verminder. Hidroliese rotsbreking, of hidrobreking, word beskou as ’n mynbouproses wat ’n hoë risiko inhou vir Suid-Afrika. Die Nama Karoo in Suid-Afrika is geoormerk vir hidrobreking en weens hierdie streek se sensitiewe ekosisteem, behoort die moontlikheid dat hidrobreking ’n toename in ramprisiko vir die streek kan inhou, beredeneer te word. Verdere risiko’s wat aan hidrobreking verwant is, gaan gepaard met die gebrek aan inligting rakende die hidrobrekingsproses, die gebrek aan kennis aangaande die gebruik van chemikalië gedurende die hidrobrekingsproses, en hidrobrekingsmaatskappye wat selektief gevaarlike chemikalië, gebruik in die hidrobrekingsproses, bekend maak.

Hierdie studie fokus op onderhoudvoering met georganiseerde gemeenskapsgroepe en rampbestuursbeamptes in plaaslike regerings in uitgesoekte dorpe in die Nama-Karoo. Die dorpe wat vir die doel van hierdie studie geïdentifiseer is sluit in Beaufort Wes, Britstown, Carnarvon, Colesberg, Graaff Reinet en Victoria Wes. Daar is op hierdie dorpe besluit aangesien die dorpe binne die voorgestelde hidrobrekingsgebied in die Nama Karoo val. Die onderhoude bied ’n unieke perspektief op die kommunikasie deer hidrobrekingsmaatskappye aan georganiseerde gemeenskapsgroepe en plaaslike regerings in die aangewese area. Die onderhoude bied ook ’n oorsig oor algemene kennis rakende hidrobreking, plaaslike water- en omgewingsbestuur en rampbestuur op plaaslike regeringsvlak.

Die studie het bevind dat al die gemeenskappe wat deel van die onderhoudvoering was, nie ewe goed ingelig was met betrekking tot hidrobreking en hidrobrekingspraktyke nie. Die antwoorde wat die georganiseerde gemeenskapsgroepe en plaaslike regering op die navorsingsvrae gebied het wissel tussen ‘goed ingelig’ en ‘hoegenaamd geen kennis’ rakende hidrobreking nie. Die georganiseerde gemeenskapsgroepe het voorts aangedui dat hulle nie bewus is van enige wetgewing, in terme van rampbestuur, nie en verskeie plaaslike regerings het ook aangedui dat hulle nie oor die kapasiteit beskik om die relevante wetgewing in hul onderskeie jurisdiksies af te dwing alvorens hidrobreking aanvang neem nie.

Na oorweging van die geweldige verskille in kennisverspreiding en die feit dat hidrobrekingsmaatskappye nie al hul prosesse en prosesvereistes openbaar nie – wat in teenstelling is met die doelstellings en doelwitte van die Rampbestuursraamwerk en die Wet op Rampbestuur – spreek dit vanself dat aanbevelings gemaak moet word om hierdie probleme aan te pak. Die studie beveel aan dat DMAF strukture en kommunikasie strukture gevorm word wat die plaaslike Nama Karoo inwoners sal toelaat om frakturing verwante inligting met meer gemak, eweredig te versprei reg oor die Nama Karoo.

Sleutelterme:

Hidrouliese rotsbreking; hidrobreking; grondwater; omgewing; besoedeling; Suid-Afrikaanse Wet op Rampbestuur (57/2002); Suid-Afrikaanse Nasionale Rampbestuursraamwerk; Nama-Karoo; ramprisikobestuur; risikobestuur; ramprisikovermindering

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DMA	Disaster Management Act 57 of 2002
DMAF	Disaster Management Advisory Forum
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
DWA	Department of Water Affairs
EIA	Environmental Impact Assessment
ICDM	Intergovernmental Committee on Disaster Management
IDP	Integrated Development Plans
KPA	Key Performance Area
MEC	Member of Executive Council
NDMC	National Disaster Management Centres of South Africa
SA NDMF	South African National Disaster Management Framework
USA	United States of America
USEPA	United States Environmental Protection Agency

CHAPTER 1: INTRODUCTION AND ORIENTATION

1.1 Introduction and orientation

Disasters are increasing worldwide, and this places a heavy strain on essential services and living conditions (Hoeppe, 2008). According to the South African National Disaster Management Framework (referred to as SA NDMF) of 2005, the South African Disaster Management Act 57 of 2002 (hereafter referred to as the DMA) serves as a guideline to an integrated and coordinated disaster risk management policy for implementation (SA NDMF, 2005). The SA NDMF and DMA focuses on prevention or reduction of disaster risk, mitigation of disaster severity, preparedness, and rapid and effective response to disasters, along with post-disaster recovery. The DMA recognises a wide range of measures that could be taken by government, civil society and the private sector in South Africa to prevent and reduce disasters, and their accompanying losses through concerted effort. It also acknowledges that there is a crucial need for a uniform approach by diverse role players and partners (SA NDMF, 2005). Any blame for failure to implement the DMA lies with the government and allocation of funding within government (Keen *et al.*, 2003). According to Ahrens & Rudolph (2006:212) institutional failure is the root cause of the susceptibility of developing countries to disaster. Coupled with disaster management, sustainable livelihoods can be achieved only if a country's governance structure allows for implementation of public policies that are conducive to economic and social development (Ahrens & Rudolph, 2006). Enabling effective governance structures within disaster risk reduction therefore requires following the SA NDMF.

The governance of disaster risk reduction is the focal point of the Key Performance Areas (KPAs) and Enablers stated within the SA NDMF, compiled in accordance with the DMA. The DMA is aimed at guiding communities to build resilience through the implementation of the KPAs and Enablers in the SA NDMF (Van Niekerk, 2005; SA NDMF, 2005). The focus of the SA NDMF is implementation of the various KPAs and Enablers to ensure sustainable development of risk assessment, vulnerability and disaster management (Van Niekerk, 2005; SA NDMF, 2005). The main focus areas of the KPAs and Enablers are, firstly, sharing good practices and lessons for facilitating disaster reduction achieved within sustainable development context, and identifying gaps and challenges within disaster management. Secondly, increasing awareness importance of disaster reduction policy to facilitate and promote implementation of policies and frameworks. Lastly, focus is on increasing reliability and availability of appropriate disaster-related information to the public and disaster management agencies in all regions (Van Niekerk, 2005). This focus ensures that governments identify disaster risk aims and objectives that they want to reach, along with how to reach objectives of the DMA through use of the SA NDMF.

The SA NDMF was developed in 2005 after recognising the need for a decentralised system of disaster management (Coetzee & Van Niekerk, 2013). The government wanted to ensure that communities were more resistant to disasters and hazards, and therefore implemented the decentralised system of governance for disaster risk management in 2002, in accordance with the DMA, although the formal SA

NDMF was only developed in 2005. This decentralised system led to each organ of state having government sphere specific responsibilities to manage disaster risk. This created a direct link between development of local municipalities, conservation of environment and groundwater for citizens, and their disaster profile (Coetzee & Van Niekerk, 2013). The decentralised system of governance has enabled various government sectors to identify the most important conservational needs (such as environmental economy, water and livelihood conservation) in their region in accordance with the SA NDMF standards. These conservational needs were identified on the basis of the national disaster profile. Local and regional governments use the national disaster profile as a basis or template for identifying local disasters for local disaster profiles (Coetzee & Van Niekerk, 2013). Each region in South Africa should therefore have its own set of identified disaster risks, based on the template profile, specific to its region (SA NDMF, 2005). The aforementioned is known as 'segmented conservation'.

The Nama Karoo region forms part of four provinces (Northern Cape, Western Cape, Eastern Cape and Free State) and therefore four conservation segments, meaning each province adheres to different conservation profiles and localised standards within the larger standardised conservation framework (Ellis *et al.*, 1999). Since the Nama Karoo stretches across more than one province, district and municipality a classification of various disaster risks and disaster profile priorities are used as guidelines for implementing conservation priorities and disaster risk management best practices as required within the SA NDMF structure. The disaster profile priorities and classifications are linked with local vulnerability, coupled with associated disaster profiles of a specific area (Ellis *et al.*, 1999; SA NDMF, 2005). The vulnerabilities and conservation systems are identified based on the use of predetermined indicator species or events within local municipal areas. These indicator species and events are used as an early warning system of impending hazards (Ellis *et al.*, 1999). The disaster management of areas, such as the Nama Karoo, has received a great deal of attention recently based on this early warning system (Palmer & Hoffman, 1997). Considering the vast expanse of the Nama Karoo and need for conservation and disaster management segments to coordinate hazard response, there is need for a visual representation of the Nama Karoo as indicated by Figure 1.1.

The Nama Karoo is a region in South Africa, considered to be the largest biome in South Africa and covers 22.7% of the South African surface (Palmer & Hoffman, 1997). The light green colour in Figure 1.1 below, illustrates the location of the Nama Karoo in South Africa along with the prospected fracking area associated with the Royal Dutch Shell plc. It is situated at an elevation of 550-1500m and is divided by the Great Escarpment into two classes according toelevation differences (Palmer & Hoffman, 1997). This region is sparsely populated and the main livelihood income of the region is wool- and meat production (Palmer & Hoffman, 1997).

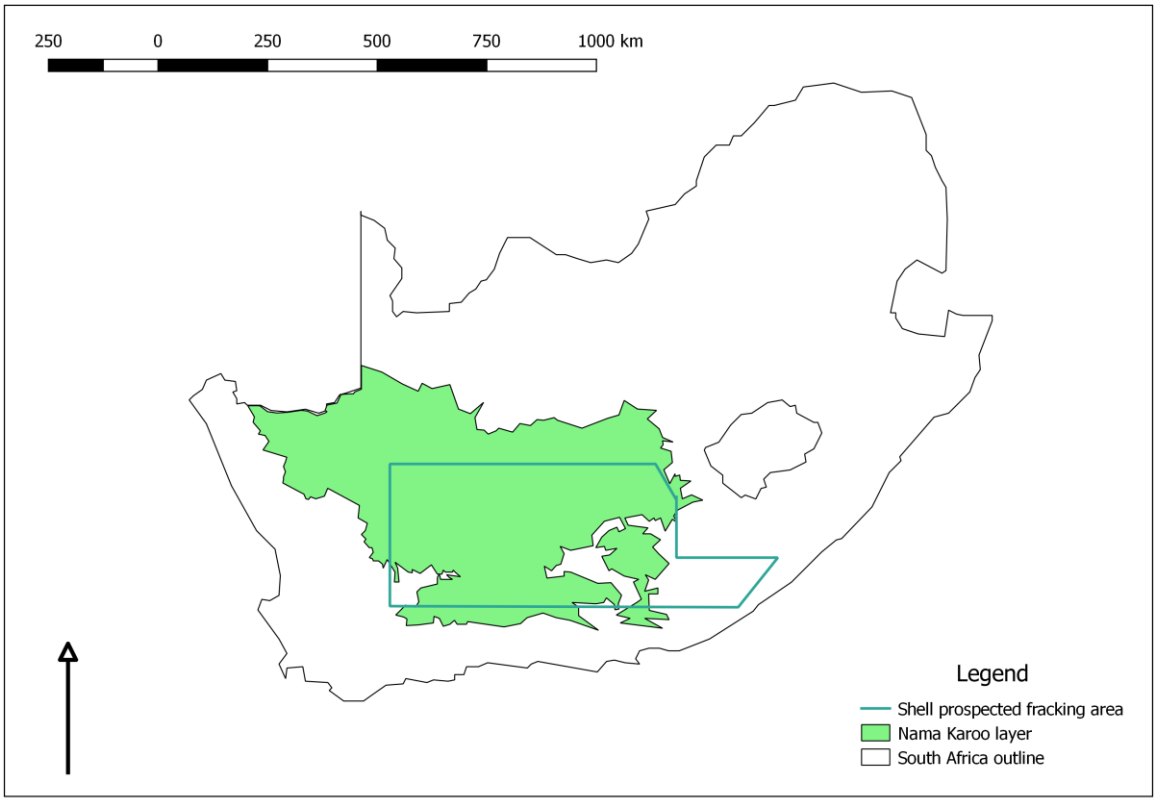


Figure 1.1: South African biomes (adapted from Kraal Media & Marketing, 2015).

The map in Figure 1.1 illustrates the Nama Karoo in relation to South Africa. The area identified as the Nama Karoo, as indicated in Figure 1.1, falls under the area set a part for fracking by Royal Dutch Shell plc as indicated by the blue frame on the map. Sections 1.1.1 and 1.1.2 of this chapter gives a description of the fracking process and requirements for the fracking process. These requirements indicate that fracking is a water intense procedure with a high risk for pollution. The area identified for fracking in the Nama Karoo is potentially sensitive to pollution, such as surface water pollution, groundwater pollution, air pollution, and soil pollution (Palmer & Hoffman, 1997). The unique environment, scarcity of water, and population in the Nama Karoo area makes it an important area to protect (ibib). Water is considered a scarce resource in this region and the population is highly dependent on the groundwater system (Palmer & Hoffman, 1997), represented by Figure 1.2 and 1.3.

Since this area is already identified as sensitive to pollution, the fracking process could have a disastrous effect on livelihoods, groundwater and environment (De Waal & Chipeta, 2013; Gandossi, 2013). Strict procedures should circumscribe the implementation of fracking to ensure that the environment is not polluted. However, implementing and incorporating procedures used to ensure environmental safety and conservation into the fracking process increases cost of fracking, and are therefore often omitted if finances are in question (Gandossi, 2013).

Establishing a sustainable conservational method in the Nama Karoo of South Africa, is of utmost importance to ensure implementation of effective conservational methods coupled with disaster

management practices (Ellis *et al.*, 1999; SA NDMF, 2005). Moreover, this area has been explored for hydraulic fracturing possibilities during 1967 by Southern Oil Exploration Company (SOEKOR), and more recently by Royal Dutch Shell plc, Falcon Oil and Gas (USA) and Sunset Energy (Australia). Figure 1.1 indicates where fracking might take place in the near future, as well as the company with rights to the prospecting area (Kuuskraa *et al*., 2011). This study only focused on the areas where Royal Dutch Shell plc (or more commonly known shortly as Shell) has gained prospecting rights for fracking. Choosing the area where Shell has gained prospecting rights, ensures that the Nama Karoo is the only biome being considered, since this study does not have the capacity to study potential fracking effects on all potentially affected biomes. Therefore the largest biome (Nama Karoo) coupled with the company which gained most prospecting rights within the Nama Karoo biome has been chosen. Only towns within the blue frame (Figure 1.1), representing the Shell fracking rights area, were therefore considered for this study. The blue framed section as indicated in Figure 1.1 corresponds to the Nama Karoo section as indicated in light green in Figure 1.1.

As indicated in Figure 1.1, Shell has obtained a substantial area for fracking related prospecting. When correlating the area obtained by Shell for fracking prospecting with the Nama Karoo Biome, Shell in large part overlays the Nama Karoo Biome. Based on this large area set apart for Shell to implement fracking which overlays the largest Biome in South Africa, the Nama Karoo, it is deemed necessary to explain what fracking is and how it could impact the Nama Karoo region (Department of Energy and Climate Change, 2013; Ellis *et al.*, 1999).

1.1.1 Fracking explained

Hydraulic fracturing - 'Shale gas fracking' - only started to be widely used during the early 21st century, although this method has been around since the 1940s (Medina & Suedel, 2015). The presence of gas reserves and development of horizontal drilling made the practice of fracking more economically viable as an energy resource, since previously only vertical drilling was used. The vertical drilling technique did not enable ample extraction of shale gas for prolonged use of a single drilling point. Even with horizontal drilling technique shale wells still have short life spans, maximum of five years, and yield less with each shale fracking (Jacobs, 2014).

Hydraulic fracturing, or fracking, is a technique that uses fluid (mainly water), which is being pumped at high pressure into rocks to create narrow fractures and create paths for underground gas to flow into drilled wells for transport to the surface (Department of Energy and Climate Change, 2013). Once fractures are created, small particles of sand are pumped down into fractures to keep them open (Department of Energy and Climate Change, 2013). The shale gas being mined is similar to conventional gas, which consists mostly of methane and is used for generating electricity, cooking, and heating. Shale

gas can also be found in shale rock formations (Medina & Suedel, 2015) associated with the shale Geology of the Beaufort and Ecca Groups within the Karoo supergroup (Fildani *et al*., 2009).

The wells are mainly drilled downward into the Ecca Group shale layers and then horizontally parallel within the shale layer, since this gives access to shale gas deposits within shale layers and several directions of drilling from this vantage point (White *et al.*, 2015). Four million gallons (15 141 647,136 liters or 15 141,647 kiloliters) of water-based fluid is needed every time a fracking fissure is made for shale gas extraction. Every underground fissure for the fracking process uses this amount of water which is mixed (Lester *et al.*, 2015) with additional chemicals and substances that make up 1% of the total solution of this 15 141,647 kiloliter mixture (Medina & Suedel, 2015). The water contains quantities of other substances, such as surfactants and acetic acid, to enhance efficiency of the fracking process (Department of Energy and Climate Change, 2013; Lester *et al.*, 2015). Acetate and formate are most likely the degradation products of polymers used in the fracking fluid which could potentially cause environmental harm (Lester *et al.*, 2015). After these fracking fluids have completed the underground fracking cycle it needs to be extracted. This extracted fluid is called flowback (Lester *et al.*, 2015; Medina & Seudel, 2015).

The main environmental concern pertains to the management of flowback, unpredictable fracking fissure reach and distribution, and fractured shale in the vicinity of groundwater systems (Medina & Suedel, 2015). Flowback refers to the fluids (used water and chemical mixture) which is extracted from the well after fracturing of the shale layer has taken place in a fracking well (Gandossi, 2013; Medina & Suedel, 2015). The efficiency of shale gas extraction is influenced by the fact that shale is found at greater depths in the prospected Nama Karoo region and the geological structure does not allow gas to move freely. Due to rock depth (Beaufort Group individual sill thickness of 100m and depths of >1000m and Ecca Group depth up to 4 692m (as found by SOEKOR in 1960s/1970s)) and structure, the stimulation of shale gas flow is dependent on fracking on a larger scale and at a higher pressure than conventional drilling (Burchi & Mechlem, 2005; Rosewarne *et al*., 2013; Van Wyk, 2013). Contamination risks could increase considering that gas fracking operates at deeper levels and therefore at higher pressures. The risks for water and groundwater contamination through fracking practices and flowback managementare linked with endangering livelihoods of inhabitants in the fracking area (Van Wyk, 2013; Van Tonder, 2012). As indicated previously in Section 1.1 the inhabitants of the Nama Karoo region rely on groundwater and groundwater systems (represented by Figure 1.2 and 1.3) for their livelihoods and survival (Palmer & Hoffman, 1997).

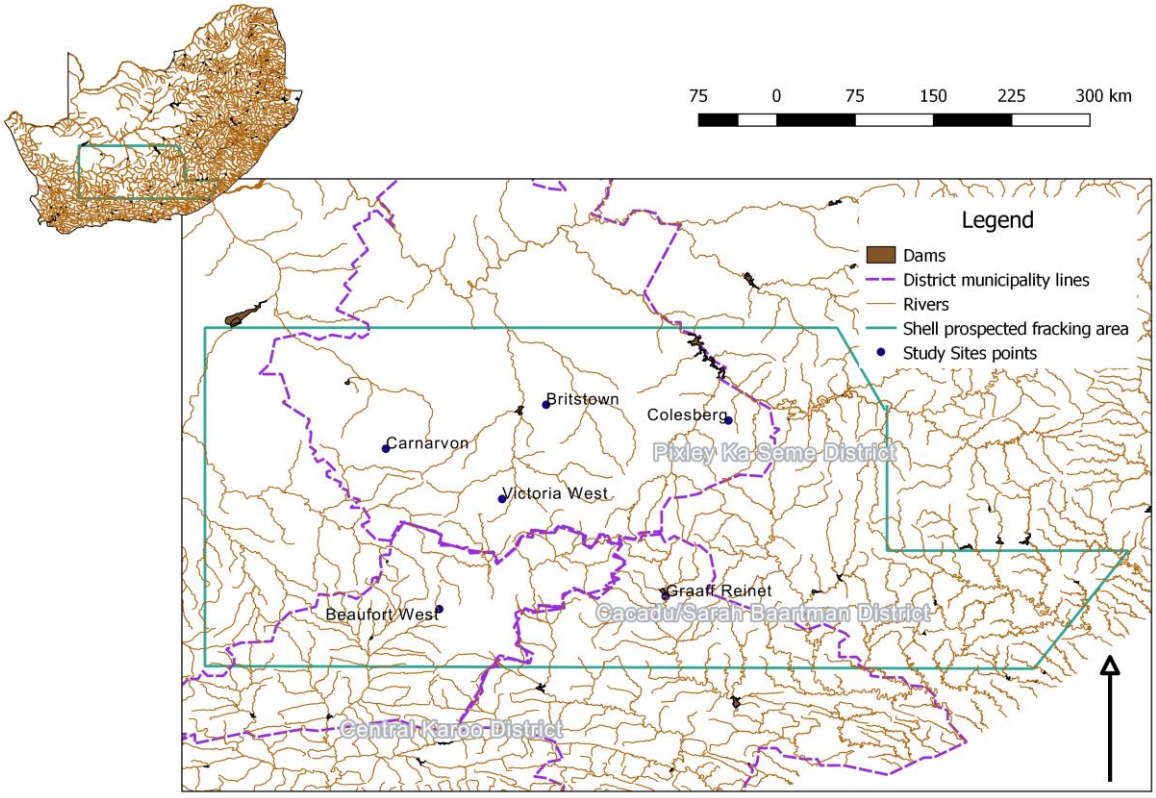


Figure 1.2: Non-perennial rivers beds and dams within the Shell prospected fracking sone.

Considering that the Nama Karoo only contains non-perennial rivers, the livelihood structure of the area is reliant on groundwater sources and systems (indicated in the map below).

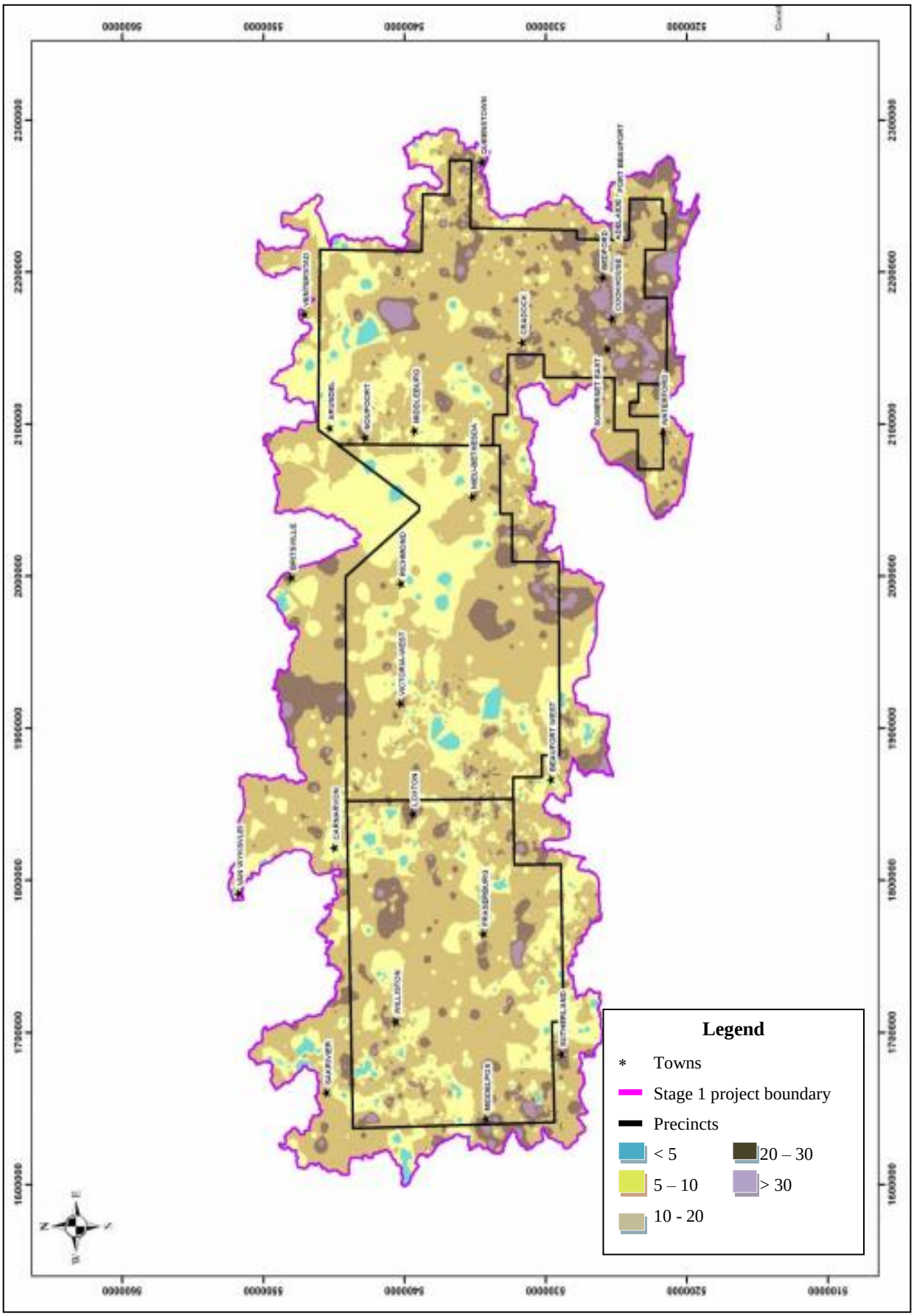


Figure 1.3: Groundwater system of the Nama Karoo (Van Tonder, 2012:9).

Ensuring that livelihoods are protected for local citizens, focus needs to be on laws and legislation that would enable protection and management of fracking within the Nama Karoo, specifically water and groundwater system protection and management.

The existing laws, such as disaster risk reduction legislation (Van Niekerk, 2005), water laws/policies (Olowu, 2014), conservation easements, and South African district and provincial environmental laws (Larson *et al.*, 2014), are not sufficient to ensure adequate management and enforcement of groundwater and ecology conservation in the Nama Karoo (Medina & Suedel, 2015). In accordance with the SA NDMF (2005) Key Performance Areas (KPAs) and Enablers, critical components of effective disaster risk reduction rely on the regulations, standards, bylaws and other legal enforcement instruments that would discourage risk-promotive behaviour and minimise potential for loss. The national, provincial and municipal departments of state assess the disaster risk management component of existing policies, regulations, by-laws and other legal instruments for their functional areas. This leads to introducing measures that enables alignment with requirements specified in the Disaster Management Framework Act of 2002 (SA NDMF, 2005). There are currently no policies pertaining to fracking and fracking impact on environment or groundwater in the Nama Karoo region of South Africa. Although there are laws that pertain to the mining industry, shale gas mining is not the same as conventional mining (Zillman, 2015:88). The DMA and SA NDMF, therefore, uses the relevant KPAs and Enablers as described in the SA NDMF to ensure adequate management of various disaster risk aspects, of which groundwater and ecology form part.

The development of fracking fields and impact of fracking on the environment, groundwater, and surrounding communities, due to discharge such as flowback (Medina & Suedel, 2015), are of importance. Disaster risk reduction plays a central role (Van Niekerk, 2005) in protecting the inhabitants of the Nama Karoo along with their livelihoods, environment and natural resources, while the economy of South Africais being augmented by fracking (Medina & Suedel, 2015). Conservation thus needs to be applied in accordance with relevant KPAs and Enablers described in the SA NDMF, ensuring that the local and provincial disaster management plans and DMA protecting these various aspects are established.

1.1.2 Influences of fracking on the economy, environment, groundwater and livelihoods

South Africa is in need of both economic opportunities and increased energy production (Danielle *et al*., 2013). Fracking could cause a national increase in employment opportunities, which in turn addresses some of the economical challenges of South Africa. The employment opportunities associated with fracking and fracking prospecting are mainly associated with individuals who obtained a tertiary qualification or those who have the relevant experience for specialised tasks associated with fracking processes (Larson *et al.*, 2014; Medina & Suedel, 2015). South Africans are, therefore, projected to also

experience a positive trend in South African economy (Larson *et al.*, 2014). Fracking could address some of the energy problems that South Africa faces (such as energy production and stability), although legislation and policies need to ensure that fracking and fracking prospecting does not continue unregulated and that the areas being fracked are protected as effectively as possible (Danielle *et al.*, 2013). Legislation and policies need to address the environment, water resources and livelihood structures to ensure that the Nama Karoo is protected for future generations (Palmer & Hoffman, 1997; Van Niekerk, 2005). The impact that fracking and fracking prospecting could have on the environment and livelihoods should be established enabling legislation and policies to be drawn up compatible and appropriate to fracking circumstances (Esterhuyse *et al.*, 2013; Gandossi, 2013).

Since Texas in the USA and Australia has been practising fracking for a few years (detailed explanation in Sections 2.2 and 2.3). Their trials and errors are useful markers to establish a guideline for South African disaster management. These markers will enable successful planning for disaster management structures which account for economic growth of fracking areas in the Nama Karoo, groundwater, environment and inherent livelihood impacts. It has, for example, been established that fracking is hazardous (Sections 1.1.1 and 2.1.3 of this document) in various ways, such as pollution of water, and environmental resources and degradation. It has also been established that fracking has an impact on the livelihoods of fracking affected communities (Zillman *et al.*, 2015). Arguments have, however been made that proper control and legislation/policies can limit impact of fracking on the environment, although not eliminating it completely (Danielle *et al.*, 2013). A chemical risk assessment pertaining to fracking needs to assess the level of potential impact of the flowback (a fracking process by-product as discussed in Sections1.1.1, 2.1.3 and 4.4) on the environment. All of these aspects pertaining to fracking and risks involved lead to the need for a problem statement.

1.2 Problem statement

The challenges of developing fracking fields or prospecting for fracking possibilities necessitate a risk analysis to ensure that adaptation and mitigation strategies can be developed for implementation (Larson *et al.*, 2014). These strategies have the function of mitigating risks that fracking or fracking prospecting poses to the environment, groundwater and livelihoods. It is not clear how current mitigation strategies are being used for legislation development, policies or plans as well as for further implementation of the developed legislation or policies in surrounding communities of the Nama Karoo (Larson *et al.*, 2014). The development of legislation and policies for fracking needs to be done before fracking commences, to exclude similar problems experienced in Texas USA and Australia. Since fracking has not been practiced in South Africa in the past, it is imperative that a proposal is presented, by provincial and national disaster management in conjunction with prospective fracking companies (in this case Shell is the focus), as to how the process works and what the process needs for successful implementation. This leads to

formulating a conceptual model which can be used to develop legislation and policies based on a conceptual risk framework, which would need to be developed by national and provincial disaster management centres (Larson *et al.*, 2014; Medina & Suedel, 2015; SA NDMF, 2005). A conceptual model has been developed by the United States Environmental Protection Agency (USEPA) to promote a general understanding of the fracking process as shown in Figure 1.4 below (Medina & Suedel, 2015).

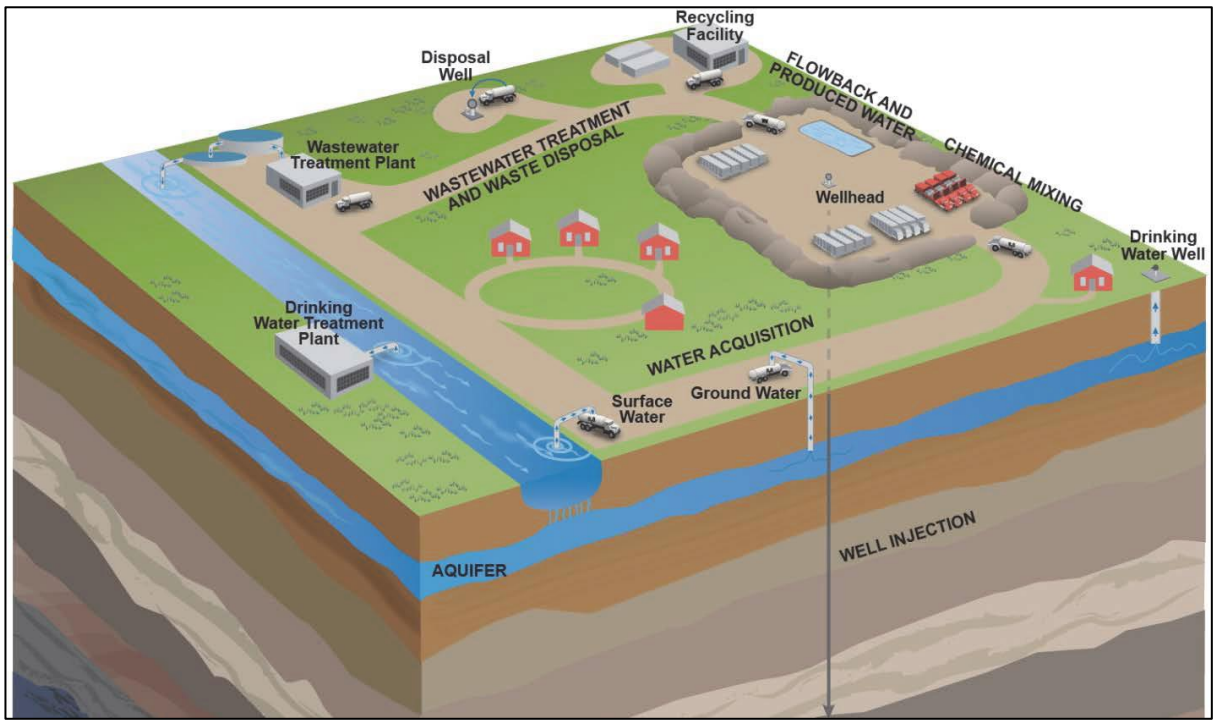


Figure 1.4: A generalised conceptual model of water moving through the fracking process (Medina & Suedel, 2015:4).

Figure 1.4 can be utilised as a starting point or baseline for mitigation strategies to be identified since it provides an example of how a fracking mine uses water during the fracking process. This model only provides an example through which possible basic risks and hazards associated with fracking could be identified. The conceptual mitigation strategies developed based on this type of conceptual model should be coupled with the SA NDMF and extensive research concerning chemicals used during the process (SA NDMF, 2005). Disaster mitigation *"refers to structural and non-structural measures that are undertaken to limit the adverse impact of natural hazards, environmental degradation and technological hazards on vulnerable areas, communities and households"* (SA NDMF, 2005:46). Disaster mitigation has a broad outline in the SA NDMF (2005), which stipulates what the function of mitigation should be in the context of disaster. However, fracking specific disaster management and risk mitigation strategies are not in place for fracking or fracking prospecting, therefore Chapter 2 and 4 stipulates the requirements and strategies for mitigating possible disasters at this phase of Nama Karoo fracking and prospecting (SA NDMF, 2005).

In accordance with the SA NDMF (2005), the critical components of effective disaster risk reduction relies on relevant KPAs and Enablers as described within the SA NDMF. The national, provincial and municipal departments of government should assess the disaster risk management component of existing relevant KPAs and Enablers, described in the SA NDMF, for their functional local areas. This leads to the introduction of measures that ensure alignment with legislative requirements specified in the DMA (SA NDMF, 2005). There are currently no policies pertaining to fracking or fracking prospecting and its impact on environment in the Nama Karoo region of South Africa. Although there are laws that pertain to the mining industry, shale gas mining cannot be compared to conventional mining (Zillman *et al.*, 2015). This means that South Africa develops new disaster risk management strategies that pertain specifically to fracking, fracking prospecting and fracking practices (Van Niekerk, 2005), in accordance with the relevant KPAs and enablers as described in the SA NDMF.

One of the challenges in the Nama Karoo to be considered is that this region is sparsely populated. This sparse population density stretches local government in implementing and enforcing laws due to capacity issues. In light of the previously mentioned challenges, a form of isolation might be occurring between towns and therefore distribution of knowledge does not occur readily between these towns. Coupled with challenge with regards to knowledge distribution and vastness of the Nama Karoo, very little is known about the vegetation, ecology, sociology, ecosystems, groundwater, and water systems in place in the area (Palmer & Hoffman, 1997). Groundwater is the main source of water in this region and is being managed without proper extraction regulation (Palmer & Hoffman, 1997). The main information concerning the environment is local knowledge which is passed on from one generation to the next (Palmer & Hoffman, 1997). Water and groundwater management is considered very important to communities in the Nama Karoo since groundwater is their main source of water. Local knowledge however is not enough to adequately manage groundwater during droughts or other extenuating circumstances (Palmer & Hoffman, 1997). The local government also needs to implement regulations for water control during droughts or other extenuating circumstances, since local knowledge cannot be assumed to be universal throughout the Nama Karoo. The culmination of the above mentioned aspects, in the Nama Karoo, are in line with the area being classified as a fragile ecosystem (Palmer & Hoffman, 1997).

The problem under investigation is that there is insufficient fracking and fracking process knowledge in the Nama Karoo local governments and local communities. The available fracking knowledge is not distributed uniformly through the whole Nama Karoo and its affected communities. Procedures to ensure that fracking occur safely and with minimum impact on the Nama Karoo environment, groundwater, and established livelihood system. Although the SA NDMF and DMA are of high standard there are still notable concerns if fracking and prospecting practices should continue. Increases in risks are coupled with omission in fracking procedure disclosure, use of fracking related chemicals, and capacity to enforce plans and policies set in place for fracking. These issues not only relate to disaster risk management and disaster management realities, but also to mismanagement and lack of policy and plan implementation in

all spheres of government. The challenges focussed on in this study are presented in the form of research questions in the section below.

1.3 Research questions

The following research questions en capsulate the problems identified above and on which this research paper focuses. Thefollowing questions are answered after completion of the study:

- What is the theoretical foundation of hydraulic fracking and the impacts thereof on the environment?
- Which sections of the Disaster Management Act (DMA) and South Africa National Disaster Management Framework (SA NDMF) pertain to successfulmanagement ofenvironment, groundwater, and livelihood risk increases coupled with possible fracking implementation in the Nama Karoo?
- What are the unique community and local government officialperspectives concerned with disaster risk management due to fracking, and common fracking knowledge and communication between Nama Karoo communities and local government?
- What recommendations can be made based on local government, organised community group, and international research information with regards to the management of disaster risk due to fracking or fracking prospecting possibilities within the Nama Karoo?

Considering these research questions, the need for further research objectives arose to ensure that the research questions are answered at the end of this study.

1.4 Research objectives

The following objectives provided the framework with which this research is conducted:

- Determine the theoretical foundation of hydraulic fracking and the impacts thereof on the environment.
- Determine which sections of the Disaster Management Act (DMA) and South Africa National Disaster Management Framework (SA NDMF) pertain to successful management of environment, groundwater, and livelihood risk increases coupled with fracking implementation in the Nama Karoo.
- Explore and analyse the unique community and local government official perspectives concerned with disaster risk management due to fracking and their general understanding of fracking through fracking company communications in the Nama Karoo.
- Make recommendations to fracking affected organised community groups and local government with regards to the management of potential disaster risk due to prospected fracking in the Nama Karoo to enable a proactive disaster management approach.

The vastness of these objectives culminated in the need for a contextualisation of the specific central theoretical statements, which further guides this study.

1.5 Central theoretical statements

Based on the explanation in Section 1.2 the focus of this research study is on the theoretical underpinning of hydraulic fracking in a Disaster Management context within the Nama Karoo Biome. There are three factual pillars that have been established for this study. Fact number one contextualises that fracking has not occurred in South Africa as yet, although SOEKOR has done prospecting during 1967 (Burchi & Mechlem, 2005; Gandossi, 2013; Rosewarne *et al*., 2013; Van Wyk, 2013). Since fracking has not occurred in South Africa the challenge is to draw parallels, with the use of case studies, between theoretical fracking of the Nama Karoo and actual fracking of countries similar to the environment found in the Nama Karoo. These parallels are drawn based on information concerning the Nama Karoo environment, groundwater, and livelihood structures. Considering Texas USA and Australia environments, groundwater systems, and livelihood structures similarities, these two countries were applicable for case study use (Esterhuyse *et al.*, 2013; Gandossi, 2013). Fact number two contextualises that the Nama Karoo is not considered a designated mining area, only farming and settlements can be found in the area (Palmer & Hoffman, 1997). The local governments in the Nama Karoo region do not have experience in dealing with mining risks and challenges. Coupled with the preceding issue, local governments lack the capacity to respond to mining related risks and disasters. There are already capacity strains on local governments in the Nama Karoo due to the vast nature of the Karoo and therefore vastness of the districts they are responsible for (Esterhuyse *et al.*, 2013; Gandossi, 2013; Palmer & Hoffman, 1997). In the rest of South Africa, mines and mining companies have been negligent in the implementation of pollution safety measures, since these measures have been deemed too expensive to implement (Gandossi, 2013). This leads one to believe that fracking companies would not abide by the relevant disaster management policies and disaster management plans either. Although South Africa has some of the best environmental, mining, water management policies, disaster management policies, and disaster management plans in the world, the assumption is that these policies and plans are not, and will not, be properly implemented (Esterhuyse *et al.*, 2013). Fact number three contextualises that the Nama Karoo is sparsely populated and also classified as a fragile ecosystem (Palmer & Hoffman, 1997). The sparse population and fragile ecosystem (as discussed in Section1.2) has a significant impact on livelihood structures of the Nama Karoo inhabitants. The sparse population and livelihood structures also add to local government capacity to implement policies and plans in the Nama Karoo. Since the disaster management policies and disaster management plans are extremely important for survival of the Nama Karoo and livelihood structures, their implementation and enforcement is imperative to the Nama Karoo and affected inhabitants (Esterhuyse *et al.*, 2013; Palmer & Hoffman, 1997).

The culmination of these three aforementioned facts, along with their discussed challenges, aid in contextualising how disaster risk increases due to fracking in the Nama Karoo. Addressing increases in risk can be executed through risk reduction plans and strategies in accordance with the relevant KPAs and Enablers described in the SA NDMF. This contextualisation will be done through a qualitative research approach, contextualised within the methodology section that follows.

1.6 Methodology

This study is guided by primary literature and secondary information sources. An empirical methodology is used, since the topic under investigation is a practical issue.

A qualitative research method is used to obtain data. Qualitative analysis is based on the interpretation of data derived from interview responses, and pictures or notes supplied by participants. During this research it was necessary to compare local government representatives' opinions and policies with one another. It is therefore imperative that a qualitative data collection method is used. The advantage of the qualitative research approach is that personal opinion is captured in the form of data, which can then be compared. This ensures a full picture concerning the importance of data to the organised community group participants, government officials, companies invested in the project and disaster management framework, and disaster management planning concerns. The following section contextualises where the contents for the literature review is found to further contextualise the objectives of this study.

1.6.1 Literature review

A literature review requires the study of books and other periodicals, such as academic journals. Gathering methods also include electronic data, such as web-based platforms or search engines. The literature review of this study mainly makes use of the following resource bases:

- Google Scholar;
- Ebscohost;
- Emerald;
- LexisNexis;
- Juta;
- Science Direct;
- SA e-Publications;
- Electronic articles and books;
- Hard copy books; and
- Distribution tracts obtained from Shell during shakeholder information sessions.

The aim of the literature review is to gain an overview of current knowledge pertaining to South African Disaster Management Acts and frameworks, with the focus on environment, livelihood, and groundwater disaster risks which accompanies the implementation of fracking, with particular focus on the Nama Karoo. South Africa does not have any disaster management plans which focus on fracking, since fracking is a new risk. Disaster management plans are, therefore, being researched to draw parallels between the links to various processes applied during the fracking procedure and disaster risk management plans. This link is explored and explained so that an understanding can be gained as to where government might need to establish more relevant disaster management plans and risk reduction strategies. These strategies address fracking related disaster risks in accordance with relevant KPAs and Enablers as described in the SA NDMF. Safety measures and implementation of the SA NDMF are related to fracking to determine how the DMA and SA NDMF could contribute in reducing adverse effects and risks coupled with fracking. As discussed in Section 1.5 of this chapter, fracking has not yet been implemented in South Africa. Due to this, an empirical study is needed since the main focus of the research is exploratory, aimed at gaining insights in local community and government perspectives concerning fracking in their area.

1.6.2 Empirical study

Empirical studies entail research that is based on observed and measured occurrences, in which knowledge is gained from experiences rather than theories or beliefs (Bryman, 2012). This research is exploratory, in which the gathered ideas and insights are the main emphasis (Bryman, 2012). This method is chosen since no previous research has been conducted into fracking policies in South Africa or into disaster management concerning environmental, groundwater, and livelihood impacts of fracking in the Nama Karoo. The need therefore exists to understand how fracking influences risks coupled with environment, groundwater resources, and livelihood in the Nama Karoo, to ensure that implementation of fracking does not commence unobstructed and without disaster risk management plans. It is important to determine what organised community groups believe and take their opinions into account, along with those of driver stakeholders behind fracking implementation. For these reasons interviews and focus groups were used to ensure that the most useful and relevant information is gained from communities and stakeholders.

Semi-structured face-to-face interviews with local government officials were held and focus group interviews were also held with organised community groups from research towns identified for this research study in the Nama Karoo region. These interviews identified organised community group and local government knowledge concerning the fracking project.

In accordance with this background, the researcher consulted organised community groups indirectly concerning the SA NDMF to determine if communities of Beaufort West, Graaff Reinet, Victoria West,

Carnarvon, Britstown and Colesberg, within the Nama Karoo, know that there is a framework in place for possible disasters, and if it is being applied to the fracking context. These organised community groups also have a chance to express their concerns pertaining to fracking in their areas, along with any other inputs they feel are relevant to protecting their livelihoods, lives, groundwater, and environment. The researcher also considers local government input with regard to fracking and possible policy or plan changes that are needed in accordance with the SA NDMF and DMA. A link is drawn between environmental and groundwater disaster risk management, which pertain indirectly to possible impacts of fracking on environmental and groundwater aspects in the Nama Karoo. The local government officials and organised community groups were asked to give their opinions concerning groundwater and environmental influence related to fracking. Furthermore, South African DMA, SA NDMF, and disaster risk plans are considered in the context of fracking and fracking risk increase management, which could lead to adverse effects on environment, groundwater, and livelihood impacts in the Nama Karoo.

Community respondent opinions aid in determining how mitigation strategies could be applied using the DMA, SA NDMF, and disaster risk plans to combat possible future disasters and risk increases caused or initiated by fracking procedures. The interviewees from local government were asked for their opinions concerning possible future disaster, related to fracking, and how they propose to mitigate these disasters through disaster management. Results from this discussion leads to an explanation of the research setting and sampling methods, which are used during this study.

1.6.2.1 Research setting and sampling

Sampling refers to the process of selecting observable respondents for interviews. The reason for sampling, is that sampling provides a small set of observations that represents a whole population (Bryman, 2012). The sampling of qualitative research is of importance since the sampling method determines quality of research and reliability thereof (De Vos *et al.*, 2011).

The survey sample is targeted at the beneficiaries of fracking (government) and local organised community groups that would be influenced if fracking took place in their area. The respondents in the organised community groups were randomly selected from target populations by calling different local businesses and consulting the owners of businesses concerning who would be interested in taking part in the focus groups. Furthermore local government officials directly associated with the fracking and environmental/disaster management issues of each town is approached to take part in the study and if they decline to take part they were consulted as to who would be a suitable alternative to them within their local government. The sample group, indicated in Figure 1.5, is from the following towns in the Nama Karoo region: Beaufort West, Britstown, Carnarvon, Colesberg, Graaff Reinet and Victoria West. These towns were chosen since they are located in the Nama Karoo and the overlapping proposed Shell gas mining area, indicated in Figure 1.5. The Shell Company holds the majority of the rights for fracking, as

indicated in Figure 1.5, and furthermore the vast majority of these fracking rights are situated in the Nama Karoo region, also indicated by Figure 1.5.

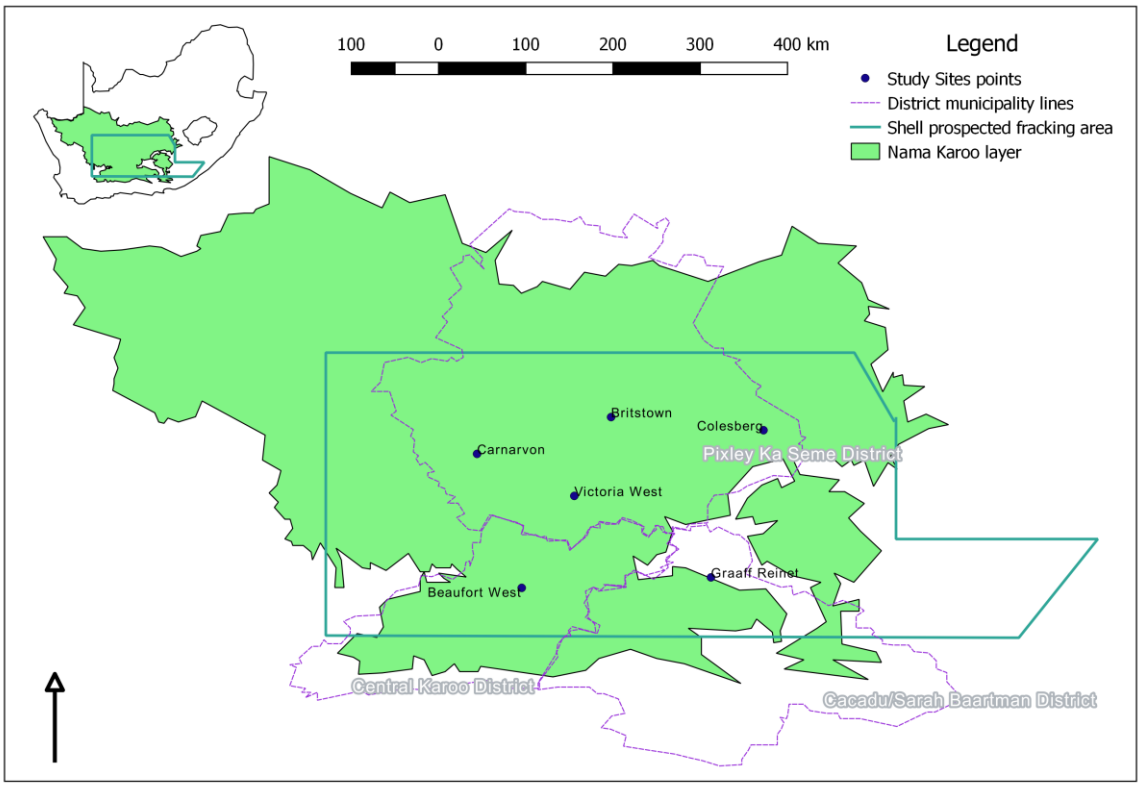


Figure 1.5: Study Sites, Nama Karoo Biome and prospected fracking area.

Purposeful sampling was applied when selecting (Teddie & Yu, 2007) the prospective fracking company, Shell, and opting to only focus on organised community groups instead of the whole community. Snowball sampling is applied after completion of interviews (Teddie & Yu, 2007) when organised community groups and local government indicate to the researcher any further relevant parties who would be willing to participate in the research, these parties are then contacted to set up further focus groups and interviews. This ensures that the research collected is as comprehensive and useful as possible. It also enables a broader perspective within these organised community groups.

A minimum of two focus groups (minimum of one organised community group and one local government official) from each of the selected towns, shown in Figure 1.5, are assembled for research. These towns are spread across the Western (Central Karoo District), Eastern (Cacadu/Sarah Baartman District) and Northern Cape (Pixley Ka Seme District). The notable difference in target groups and also the difference in provincial and district setting, require further contextualisation in the following section which is focused on data collection for this study.

1.6.2.2 Data collection

The data collection comprises of qualitative research methods, which consist of interviews and focus groups. The main sampling techniques are focus groups with organised community groups, which consist of between four and 10 organised community group representatives and face-to-face interviews with local government officials from each town. An interview in this case consists of a face-to-face or telephone conversation. The interviews were recorded, with participant consent, by voice recorder to ensure that information is not lost and to ensure that data can be more representative of participants' opinions and precisely what was said during interviews. A question template, attached in the annex, was utilised that allows for improvisation. All questions on the template were posed to the participants. Organised community groups and local government officials were asked to share their experiences and opinions in response to the relevant template of questions. The questions asked during interviews and focus groups allow individual input due to the semi-structured nature of interviews and focus groups. The participants were chosen randomly and genders were not distinguished. A minimum of one group was assembled, in each town, from organised community groups. These groups were representative of the knowledge that organised community groups in the selected towns have, pertaining to policies and fracking.

A pilot study done in Beaufort West, indicated on Figure 1.5, with organised community group members and a government official, following the method noted in the data collection section above. The pilot study was aimed at identifying any problems with questions, context or other deficiencies. The study feasibility was tested, along with the measurement instruments and technical instruments meant to be used during this study (De Vos *et al.*, 2011). Data collection was divided into two batches due to the vast distance between towns, indicated in Figure 1.5. The first data collection batch is representative of Britstown, Carnarvon and Victoria West local government and organised community groups, which are all in the Northern Cape. The second batch is representative of Beaufort West, Colesberg and Graaff Reinet local government and organised community groups. The sample batch containing Colesberg is done second since their local government and organised community groups proved challenging to gain access to. The data collection is done during March 2016 before school holidays to ensure maximum accessibility to participants. All data collection is done within the space of seven working days after focus groups and local government appointments are made. A day is set aside for each town to ensure that all participants are approached and take part in the interviews. This also allows the researcher to follow up on snowball sample information. When the relevant parties mentioned during snowball sampling were not available they were later contacted for a telephone interview if they were willing. After the pilot study the necessary adjustments were made and after all the data has been collected data was analysed as discussed below in Section1.6.2.3.

1.6.2.3 Data analysis

The information gathered during face-to-face interviews and focus groups are analysed along with the literature collected for this study. The usefulness, reliability and validity of datasets were evaluated to ensure that the quality is adequate for research purposes. The data that has been identified as incomplete or unreliable are indicated although not used (Bryman, 2012).

During the qualitative analysis, information gained from interviews, pictures or notes supplied by participants has been interpreted. The data was analysed according to a literal text analysis, flexible text reading or interpretive reading of the text. Flexible text reading refers to a non-judgemental approach that takes the readers frame of reference into account (Guest *et al.*, 2013). The reader's frame of reference was noted to ensure that any personal conflict, known or unknown could be identified as subjective on the reader's part. This creates a context that relates to the way the reader would interpret data, knowingly or unknowingly (Guest *et al.*, 2013). Relationships were then identified between variables with the use of comparative methods, and data differences and discrepancies are identified (Bryman, 2012).

There are multiple ways to conduct qualitative data analysis and therefore there is no single right way to do qualitative data analysis. There is always a need for more information concerning the qualitative analysis conducted to ensure complete data analysis. Qualitative data is an ongoing process that uses open-ended data, which leads to a tailored method of analysis as required (De Vos *et al.*, 2011). Strategies for qualitative data analysis therefore range from informal to formal strategies (De Vos *et al.*, 2011). During this research project, a semi-formal approach was taken when conducting the qualitative research. Computers were not used during the process of obtaining data, only to analyse obtained data (De Vos *et al.*, 2011). The following steps were taken during the data analysis process of this study (De Vos *et al.*, 2011):

- Planning for recording of data;
- Data collection and preliminary analyses;
- Managing the data;
- Reading and writing memos;
- Category generation and data coding;
- Testing emergent understanding and alternative explanation searches;
- Developing typologies and interpretations; and
- Presentation of data.

During data collection and analysis phases of the study, various ethical considerations (as discussed in Section1.6.2.4) were established and followed to ensure reliability of all data used in this study.

1.6.2.4 Ethical considerations

The following list of ethical considerations is applicable to this study (Bryman, 2012):

- Voluntary participation and informed consent;
- The participants did not experience physical or psychological harm during the research;
- The participants were assured of their privacy, anonymity and confidentiality during and after the research for the study;
- The participants were informed of the study aims, the purpose and the procedure, and were not deceived in any way;
- The research was done in a manner that is gender and culture sensitive; and
- The reporting and analysis of the obtained data was done on an ethical level, the research methods are shared and acknowledgement is given to the participants and sources that were consulted during the research project.

This section concludes the research methodology that was followed for the duration of this study. In relation to the methodology, problem statement, research questions, and research objectives it is imperative to also contextualise the significance of this study.

1.7 Significance of the study

The importance of South African disaster management Acts, framework and plans that address fracking directly or indirectly are demonstrated by this study, with a focus on the SA NDMF. This framework along with the DMA shows that there are certain requirements for implementation of mitigation strategies to ensure that future disasters are planned for (SA NDMF, 2005). The aim of this study is to ascertain where fracking influences lives, livelihoods, environment, and groundwater with an increase of pollution risk in the Nama Karoo and how the DMA, SA NDMF, and plans can be implemented to prevent unnecessary disaster risk.

Moreover, the Nama Karoo participants were able to express any concerns pertaining to fracking and the potential for pollution and disaster risk. The inhabitants have been raising issues concerning fracking, particularly in Graaff Reinet and Beaufort West, since they are concerned about fracking development. Currently organised community groups in the Nama Karoo, indicate that government is ignoring the concerns related to fracking (Treasure Karoo Action Group, 2014). Policies in South Africa regulating fracking have been complaisant or changed in favour of fracking companies. This means that all the policies and legislation which protected the South African environment from fracking and related prospecting has been changed in such a manner that legislation allows fracking companies to operate and engage in activities that could heighten disaster risk of communities in the area. This research is aimed at identifying gaps in the DMA and SA NDMF sanctioning that fracking and fracking risks are addressed

from a disaster risk management perspective in accordance with the relevant KPAs and Enablers as described in the SA NDMF. The provisional chapter lay out indicates where the information concerning the various aspects in Chapter 1 can be found for an in depth understanding.

1.8 Provisional chapter layout

This study is structured as follows:

Chapter 1: Introduction

Chapter 1 comprises of an introduction to the study. The problem statement, research questions, objectives, methodology and significance of the study isdiscussed.

Chapter 2: Literature Review

This chapter contains a discussion of the theory of fracking in the Nama Karoo and policies pertaining to disaster risk reduction, and disaster risk management policies, plans, and frameworks, as well as the environmental impact fracking could have on the area allocated for fracking purposes. This report is then corroborated by various other literature sources to provide a better understanding of evidence at hand from Australia and Texas.

Chapter 3: Data Analysis

This chapter includes a report on findings of research and its relevance reported. An integrative approach is taken to ensure that the theory context and data is represented coherently. The data and findings are therefore discussed at length within the context of the theory that South Africa's current disaster risk plans, Acts, and frameworks are presumed as insufficient to ensure safe fracking in the Nama Karoo region. The data is also discussed in accordance with the relevant Key Performance Areas (KPAs) and Enablers, as described in the South African Disaster Management Framework (SA NDMF).

Chapter 4: Conclusion and Recommendations

A summary is provided in this chapter with relation to the specific research questions as posed in Chapter 1. After the research questions have been summarised, a discussion follows with recommendations concerning the findings and discussed theories.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

In Chapter 1 the proposal for this research was conducted. Chapter 1 provided the orientation of this research study and background concerning fracking and where fracking is proposed in South Africa. In the problem statement of Chapter 1 the research problem was identified as, the need to identify which South African Disaster Management plans and frameworks would need to be applied and implemented to ensure safe fracking. Research questions and objectives were formulated for research guidance. The focus of the research questions are on underpinning fracking in fragile ecosystems, determining which South African Disaster Management plans, and frameworks focused on reducing disaster risk in accordance with relevant KPAs and Enablers as described in the SA NDMF (SA NDMF, 2005). A central theoretical statement was given to further explain the chosen research questions and objectives in context of the view point taken by this study concerning fracking in South Africa, the Nama Karoo local government capacities, and the Nama Karoo as a fragile ecosystem. The methodology, which is followed for this research study was discussed, of which this chapter forms part and significance of this study was also given.

The aim of Chapter 2 is to give an overview of knowledge, which is currently available concerning fracking procedures. Focus is mostly on South African knowledge concerning fracking processes and Disaster Management structures. Places, such as Texas and Australia, broaden the concepts concerning fracking, since fracking is not hitherto implemented in South Africa (Esterhuyse *et al.*, 2013; Palmer & Hoffman, 1997; Zillman *et al.*, 2015). This chapter explores influences of fracking on communities and environment in Texas and Australia with the use of case studies. The case studies from Texas and Australia create a picture of, which environmental and socio-economic challenges could be expected if fracking is implemented in South Africa. This connection enables a more direct understanding of the dangers if laws were not implemented and ensuring that adequate laws and frameworks are in place before fracking commences in South Africa (Ellis *et al.*, 1999; Zagonari, 2015). The National Disaster Management Centres of South Africa (NDMC) are responsible for involving and collaborating with the various governmental spheres to ensure that disaster risk is reduced. This chapter aims to show where the DMA and SA NDMF need to be implemented and how it could address fracking risks in the Nama Karoo of South Africa (Ellis *et al.*, 1999; SA NDMF, 2005; Zagonari, 2015). The Nama Karoo, where fracking is proposed to take place, is considered to be a fragile ecosystem (Ellis *et al.*, 1999) and this led to the objective of conducting research regarding the DMA and SA NDMF with indirect relation to fracking. Therefore, fracking needs to be understood, and the knowledge and need surrounding fracking should be contextualised within the South African framework, explained in the following section.

2.1.1 The rational for fracking in South Africa

The South African Government is in need of an economic increment and an increase in energy production (Danielle *et al.*, 2013). Fracking processes and gas mining addresses some of the energy problems South Africa faces (such as energy production) and it could also improve the country economy as a whole, since natural gas can be used to generate electricity (Danielle *et al.*, 2013). This need has led the South African Government to explore environmentally unfriendly processes for obtaining energy and electricity, such as fracking (Zhou, 2009).

Fracking is considered an environmentally unfriendly process which requires legislation to ensure that fracking does not continue unregulated. The areas which are proposed for fracking also need to be protected and well managed to minimise environmental risks (Danielle *et al.*, 2013). Since fracking is a water intense mining procedure, water resources will be strained under the additional demand of fracking processes, when fracking starts taking place (Zhou, 2009). This strain could cause government to review disaster management plans, under obligation, to ensure effective disaster risk monitoring of fracking, protection of environment, and protect livelihoods of communities (Zagonari, 2015).

Considering that the proposed Nama Karoo fracking area reaches over boundaries of four provinces, disaster risk monitoring aids in addressing community livelihood security, risk management and monitoring, and environmental risks (Zagonari, 2015). The Intergovernmental Committee on Disaster Management (ICDM) with the NDMC should therefore draw up, and approve, a disaster management plan which all four regions would follow. The ICDM and NDMC guidelines incorporate and strengthen their policy implementation concerning fracking, environmental protection, livelihood protection, and fair distribution of groundwater resources (Van Niekerk, 2005). The guideline ensures that a baseline is established and followed when South African Disaster Management plans and frameworks are implemented and/or developed concerning fracking processes and management (Van Niekerk, 2005).

Ensuring successful implementation of South African Disaster Management Plans and frameworks requires an understanding of fracking process and risks involved with fracking (Van Niekerk, 2005; Zagonari, 2015). The following overview of fracking links with the description of fracking in Chapter 1. The information represented in Sections 2.1.2 and 2.1.3 below aids in forming a comprehensive idea of what fracking is, the risks revolving around fracking, and possible disaster management implementation challenges which could be faced.

2.1.2 Overview of fracking

As explained in Chapter 1 hydraulic fracturing (fracking) is based on a method which uses a fluid mixture, mainly consisting of water. The water is pumped underground with a mixture of chemicals,

which is then used as an agent to apply enough pressure, when pumped underground, for rock fracturing to take place. The chemicals are used to stabilise rocks once fracturing has occurred (Jacobs, 2014). The fracking process does not allow proppant use, and therefore fracture conductivity is decreased (Gandossi, 2013). Along with keeping fractures open, the water based-fluid composition contains acetic acid to prevent precipitation of metal oxides, which could also close fractures (Lester *et al.*, 2015). Since the additional compounds make up 1% of the total solution, it is important to note that they are still a major environmental concern (Medina & Suedel, 2015). Once fracturing has occurred underground and gas starts moving to the surface, fluid is extracted in the form of flowback and chemicals start to keep the fractures from closing (Jacobs, 2014).

Flowback refers to the used water and chemical mixture which is extracted from the fracking well, meaning that it is the fluid extracted after hydraulic fracturing has taken place in a specific well and its process is completed, allowing fluid extraction (Gandossi, 2013). Flowback comes in various forms, depending on which mixture is used during the fracking process (Bomgardner, 2012). Fracture fluid used during the fracking process ranges from water to slick water and gels, all of which requires fresh water as a base fluid to achieve the required consistency infracturing fluid composition, and to obtain optimal fracture results (Boschee, 2012). Table 2.1 below gives a brief overview of different base fluid type options for the fracking process.

Table 2.1: The different fluids which can be used as the base fluid for hydraulic fracturing (Gandossi, 2013).

Base Fluid	Fluid type	Main Composition
Water Based	Slick water	Water + sand + chemical additives
	Linear fluids	Gelled water, GUAR < Hydroxypropyl Guar (HPG) (all linear gels are guar), Hydroxyethyl cellulose (HEC), and Carboxymethyl hydroxypropyl guar (CMHPG) (Gandossi, 2013).
	Cross-linked fluid	Cross linker + GUAR, HPG, CMHPG and Carboxymethyl Hydroxyethyl cellulose (CMHEC) (Gandossi, 2013).
	Viscoelastic surfactant gel fluids	Electrolyte + surfactant.
Foam Based	Water based foam	Water and Foamer + Dinitrogen or Carbondioxide.
	Acid based foam	Acid and Foamer + Dinitrogen
	Alcohol based foam	Methanol and Foamer + Dinitrogen
Oil Based	Linear fluids	Oil, Gelled Oil
	Cross-linked fluid	Phosphate Ester Gels
	Water Emulsion	Water + Oil + Emulsifiers
Acid Based	Linear	-
	Cross-linked	-
	Oil Emulsion	-

Alcohol Based	Methanol/water mixes or 100% methanol	Methanol + water
Emulsion based	Water-oil emulsions	Water + oil
	Carbon dioxide-methanol	Carbon dioxide + water + methanol
Other fluids	Liquid carbon dioxide	Carbon dioxide
	Liquid nitrogen	Dinitrogen
	Liquid helium	Helium
	Liquid natural gas	Liquefied Petroleum Gas (LPG) (Butane and/or Propane)

Table 2.1 indicates that the majority of processes use water and additional chemicals are added to the solution comprising of surfactants, gelling agents, propants, and biocides. The use of afore-mentioned is required to ensure that the fracking process is successful (Glass, 2011). The propants are sandy materials, which are used to keep fractures open in the rock layers. The uses of gelling agents are to aid the sand-water mixture in prying open fractures in the rock layers. These gelling agents are known as guar gum and xantham gum (Glass, 2011). Surfactants are the largest chemical component, by weight, used in the 1% chemical composition. These chemicals are prone to migrate to the surface of a substance. The use of these chemicals is to reduce surface friction during the fracking process, and these surfactants are considered to be toxic to animals and ecosystems (Glass, 2011). The biocides are used to kill bacteria which are naturally present in fresh water used for fracking. Acidising is performed as a process before, or during fracking. The process requires pumping acid into the rock formation so that fractures in the well open more effectively. The acid used in most cases is hydrochloric acid (Glass, 2011).

Table 2.1 also represents alternatives to eliminate water use in the fracking process by using air, liquid helium, dinitrogen or carbon dioxide (Gandossi, 2013). Different fracking fluid bases can result in significant differences in natural gas extraction, depending on the geological composition of an area, climate and also accessibility to alternative fluid bases. Since the essence of fracking mining practice is to extract shale gas as efficiently and cost effectively as possible, it has been proposed that water based fracking processes yield the best shale gas amounts in the Nama Karoo (Kurth, 2012). The shale gas is too deep and also varies too much in depth for other fluid bases to be feasible for the fracking process in the Nama Karoo (Gandossi, 2013). These processes were therefore not proposed for South African fracking processes (Gandossi, 2013). However, the chosen fracking technique is a water intensive mining process and it needs to be managed as cost efficiently as possible to ensure profitability (Kurth, 2012). Profitability could be influenced if the area being mined does not have sufficient water to sustain the fracking process, as is the case in the Nama Karoo. These water depth variations, water scarcity of the Nama Karoo, and also sensitivity of environment, leads one to take a closer look at environmental impacts and risks fracking could demonstrate (Merrill & Schizer, 2013; Netshishivhe, 2014; White *et al.*, 2015).

2.1.3 Environmental impacts of fracking

As with any mining process, there are various environmental impacts linked to fracking (Merrill & Schizer, 2013). Doing an environmental impact assessment (EIA), which determines advantages and disadvantages of fracking along with sensitivity of the prospected area, should aid the government in drawing up response plans for possible future disasters pertaining to fracking processes in the Nama Karoo. Response plans align with conservation practices by identifying possible environmental impacts (Netshishivhe, 2014; White *et al.*, 2015).

Conservational practices need to be implemented if the flowback, containing this 1% of potentially harmful chemicals, is improperly managed and supervised. This need for supervision and management is especially important, since the area being prospected is relatively large (Palmer & Hoffman, 1997). Table 2.2 below indicates all the possible chemicals, which make up the 1% of fracking chemicals, considered the main pollutant mentioned in Section 2.1.2 of this chapter. All of these chemicals are not necessarily used and use thereof is determined by well depth and rock layer composition. None of these parameters have been established for the Nama Karoo, since fracking is still in the planning and prospecting phase (Dundon *et al.*, 2015). Table 2.2 below also contains environmental impacts the various chemicals, which are mixed with the base fluids, can have on the environment. This is important since the research focuses on how the SA NDMF and DMA need to be implemented to enable safer fracking (Earnhart & Glicksman, 2015). These environmental impacts therefore serve as indicators of how the chemicals can endanger environment and groundwater when used unsafely or without proper regulation (Branscomb, 2013).

Table 2.2: The various chemicals used in the fracking process (Dundon *et al.*, 2015).

Chemical Name	Chemical Purpose	Product Function	Environmental impact
Hydrochloric Acid	Helps dissolve minerals and initiate cracks in the rock	Acid	If it dissociates into chloride and hydronium ions in water it will lower the pH of the water. If it becomes a gas it can cause eye, skin and respiratory irritation. This does not accumulate in the food chain (ATSDR, 2002).
Glutaraldehyde, Quaternary ammonium Chloride, Tetrakis Hydroxymethyl Phosphonium Sulphate.	Eliminates bacteria in the water that produces corrosive by-products	Biocide	Glutaraldehyde is readily biodegradable under dilution (OECD SIDS, 2008:3, 8). Quaternary ammonium Chloride is biodegradable in biological systems including surface water, soil and groundwater under aerobic conditions (Tezel, 2009:2). The Tetrakis Hydroxymethyl Phosphonium Sulphate contains functional groups that hydrolyze under environmental conditions to pH 5-9 (NLM, 2012).
Ammonium Persulphate, Magnesium Peroxide, Magnesium Oxide	Allows a delayed breakdown of the gel	Breaker	Ammonium Persulphate is toxic in concentration when not ionized (OECD SIDS, 2004:28). Magnesium Peroxide/oxide does not naturally occur. Decomposition products cause environmental concerns since these products release corrosive vapours (Aphane, 2007).

Chemical Name	Chemical Purpose	Product Function	Environmental impact
Sodium Chloride, Calcium Chloride	Product stabiliser	Breaker	Sodium Chloride is harmful to aquatic organisms and humans with high blood pressure (Kelly *et al.*, 2010:3). Calcium Chloride negatively affects soil dwelling organisms and plants. It forms inorganic and organic salts in soils and water. It is also very mobile in soils (OECD SIDS, 2002).
Choline Chloride, Tetramethyl ammonium chloride, Sodium Chloride	Prevents clays from swelling or shifting.	Clay Stabilizer	Choline Chloride is biodegradable and has no negative impact on organisms (BALCHEM, 2014). Tetramethyl ammonium chloride is considered to be a level two oral toxin. This means that it is a very toxic chemical. It's non-biodegradable and it's highly mobile in soils (Stringfellow *et al.*, 2014). Sodium Chloride is widely used and not considered a concern (Stringfellow *et al.*, 2014).
Isopropanol Methanol	Product stabiliser and/or winterising agent	Corrosion Inhibitor/ Non-Emulsifier/ Surfactant	Isopropanol and methanol is readily biodegradable (Stringfellow *et al.*, 2014).
Formic Acid Acetaldehyde	Prevents the corrosion of the pipe	Corrosion Inhibitor	Both will have adverse effects on surface and groundwater if released into the environment (Stringfellow *et al.*, 2014).
Petroleum Distillate, Hydro treated light petroleum distillate	Carrier fluid for borate or zirconate cross linker	Cross linker/ Gelling Agent/ Friction reducer	Petroleum Distillate emits carbon, a greenhouse gas, into the atmosphere (Costa *et al.*, 2011). Hydro treated light petroleum distillate is toxic to aquatic life with lasting effects (Shell, 2012).
Potassium Metaborate, Triethanolamine zirconate, Sodium Tetraborate, Boric Acid Zirconium Complex Borate Salts	Maintains fluid viscosity as temperature increases	Cross linker	Potassium Metaborate is toxic when not diluted sufficiently(OECD SIDS, 2001). Triethanolamine zirconate is not toxic although more data is needed (Stringfellow *et al.*, 2014). Sodium tetraborate has been proven to be a category 4 toxic substance (Stringfellow *et al.*, 2014).
Ethylene Glycol Methanol	Product stabiliser and/or winterising agent.	Cross linker/ Gelling Agent	Low acute toxicity in small doses and irritation increases with doses (Gomes *et al.*, 2002).
Polyacrylamide	"Slicks" the water to minimise friction	Friction Reducer	Improves soil infiltration (Sojka *et al.*, 2007).
Methanol Ethylene glycol	Product stabiliser and/or winterising agent	Friction Reducer	Does not hydrolyse in surface water only in the atmosphere (Dobson, 2000).
Guar Gum Polysaccharide Blend	Thickens the water in order to suspend the sand	Gelling Agent	This substance is bio-renewable (Elchinger *et al.*, 2011).

Chemical Name	Chemical Purpose	Product Function	Environmental impact
Citric Acid Acetic Acid Thioglycolic Acid Sodium Erythorbate	Prevents precipitation of metal oxides	Iron Control	Acids are freely soluble in water at environmentally relevant pH values (OECD SIDS, 2001). Sodium Erythorbate does not affect pH or the water activity (Redondo, 2011).
Lauryl Sulphate	Used to prevent the formation of emulsions in the fracture fluid	Non-Emulsifier/ Surfactant	This substance is biodegradable under aerobic and anaerobic conditions (Bondi *et al.*, 2015).
Sodium Hydroxide, Potassium Hydroxide, Acetic Acid, Sodium Carbonate, Potassium Carbonate	Adjusts the pH of fluid to maintain the effectiveness of other components, such as cross linkers	pH Adjusting Agent	Sodium/ Potassium Hydroxide are toxic in high concentrations in water. It also does not accumulate in the food chain(OECD SIDS, 2001). Sodium/ Potassium Carbonate are inorganic. Increases in sodium, bicarbonate and pH needs to be monitored to identify anthropogenic addition (OECD SIDS, 2002).
Copolymer of Acrylamide and Sodium Acrylate Sodium Polycarboxylate Phosphonic Acid Salt	Prevents scale deposits in the pipe	Scale Inhibitor	Copolymers alter physical, biological and chemical properties of soil which can improve or decrease soil performance (Sojka *et al.*, 2007). This substance also speeds up decomposition of raw materials (Sojka *et al.*, 2007).
Naphthalene	Carrier fluid for the active surfactant ingredients	Surfactant	Hazardous to aquatic environment since they are mobile and toxic (Irwin, 1997).
2-Butoxyethanol	Product stabiliser	Surfactant	The substance has a short half-life in the atmosphere and therefore is not considered of high environmental significance (Wess & Ahlers, 1998). The substance is also readily degraded by microorganisms (Wess &Ahlers, 1998).

Table 2.2 indicates that some chemicals are considered biodegradable under specified conditions, for example Lauryl Sulphate, as opposed to other chemicals which are considered toxic to the environment, such as Sodium Hydroxide. The vast difference in the associated environmental impacts shows that all the chemicals used during fracking are not necessarily harmful to the environment when remaining chemically unmixed. The concern for flowback contaminating environment is associated with mixing the chemicals and chemicals not being used as separate chemical entities during the fracking process.

Due to the diversity of the fracking process and various mixtures which could be used during the fracking process it is important to research areas which have similar environments to the proposed Nama Karoo fracking area (Chen *et al.*, 2015; Netshishivhe, 2014). Similar environments will aid in decision making processes and possibly divert decision makers from mistakes which have already been made. For this reason Texas in the USA and Australia have been chosen as viable case studies for background research

(Medina & Suedel, 2015). In the next section the case study of Texas is firstly presented followed by the case study of Australia.

2.3 Hydraulic fracturing and fragile ecosystems – the case of Texas

Texas is used as a reference, since fracking has been implemented in the Texas area extensively since 1949 (Netshishivhe, 2014). The geological structures from Texas and South Africa are similar, although there are small differences which can have a significant impact on useable fracking processes in South Africa (Medina & Suedel, 2015). There are limitations associated with understanding how fracking affects the underground shale rock layer during fracking processes. These limitations refer to: limited understanding of rock fracture patterns and processes in the shale rock layer; ability to predict and quantify permeable fracture networks in subsurface areas before drilling; and accuracy and precision of determining geometry of shale formation and aquifers in the subsurface level, especially those areas with complex geological histories (Healy, 2012). The limited data currently available on which chemicals are used during fracking, for the 1%, and also exact amounts of these chemicals (refer to Table 2.2) used per fracking process, paints a picture showing the damage fracking has done on Texas's environment and environmental health (Ridlington & Rumpler, 2013).

The use of hydraulic fracturing for exploiting shale oil and gas reserves in the USA has raised concerns about the effects on human health and environment. Environmental impacts in Texas due to fracking includes: water pollution from fracking fluids spillage; methane leaking into the groundwater table;and air pollution from toxic emissions, which cause acute and chronic health problems for communities living within the proximity of the fracking well (Ridlington & Rumpler, 2013). The process coupled with preparing a designated area for fracking, damages biodiversity, integrity of landscapes and habitats, and also contributes to water pollution problems (Ridlington & Rumpler, 2013). Economic implications related to fracking, notably imposes damage to the environment, public health, and public infrastructure, which entails significant economic costs (Ridlington & Rumpler, 2013). These concerns mostly centre on the fact that fracking causes drinking water pollution and groundwater pollution (Brady, 2011). Since cognisance is taken that fracking processes use chemicals established as toxic to humans and wildlife, it is imperative to limit the pollutant exposure as far as possible (Brady, 2011). In light of these possible problems it is imperative to properly prepare an area for fracking and also to take safety precautions seriously.

The scale and severity of fracking impacts should be regulated, in due course, to ensure environmental protection and public health protection against fracking (Ridlington & Rumpler, 2013). Loopholes are being addressed by policymakers to make provision for environmental laws and fracking damages (Schaeffer & Bernhardt, 2014). The natural heritage could be protected through use of these steps and

therefore fracking will be kept from national parks, national forests and sources of drinking water (Ridlington & Rumpler, 2013). For example, the main prevention for groundwater pollution is considered to be adding a permanent cast on wells running through fresh water strata. This led to amendments being made by fracking companies to address the concerns indicated by citizens (Brady, 2011). Protection of the Texas environment depends on the environmental protection agency which is required to contain and address complaints of environmental lobbyists. In essence the regulations of the Texas area are still seen as "pro-fracking", although steps have been taken to address this (Willis, 2013). Based on environmental protection requirements an immediate moratorium is in order in states, such as Texas, where fracking is already underway. The moratorium calls for government to reduce environmental and health impacts of fracking (Ridlington & Rumpler, 2013), which leads to identifying laws, legislation, acts, and policies pertaining to environment and groundwater (Cobbing, 2014; Knüppe, 2011; Solomon & Hughey, 2007). The following case study contextualises the problems Australia has encountered concerning fracking implementation in their country.

2.4 Hydraulic fracturing and fragile ecosystems – the case of Australia

The company Santos has been using fracking to produce oil and gas in South Australia and Queensland since 1954 (Santos, 2016). According to water research studies done in Australia, Santos has made sure that fracking was undertaken safely (Healy, 2012; Santos, 2016). The reason fracking is being implemented in Australia is to provide more energy to meet growing global demand for energy and to keep energy prices reasonable for consumers (Santos, 2016). In Australia the fracturing fluid composition is laid out as 90% water, 9.5% sand and 0.5% chemical additives. Their use for the chemical additives is to reduce friction, remove bacteria, and dissolve some minerals and to improve transportation of sand into the underground fracking zone (Healy, 2012; Santos, 2016). According to Grudnoff (2014:44) and Healy (2012:4-5) the chemicals used in fracking are heavily diluted and it makes up between one and ten percent of the fracking fluid. Although this is considered to be a heavily diluted mixture, the large volume of fluids required per well requires 18 500kg of these chemicals to be used (Grudnoff, 2014; Healy, 2012; Moss *et al.*, 2013). According to Santos (2016:2) fracking chemicals used in Australia increases the gas flow from a well, which leads to fewer wells required to deliver the same amount of oil or natural gas. This is viewed as good news by Santos (2016:2) for landholders, and for environment and health concerns (Healy, 2012; Jong & Jenkins, 2014).

Although this may be the case, according to Santos, the chemicals used in fracking are still considered to be of public concern (Grudnoff, 2014; Healy, 2012). The chemicals have dangerous consequences although the current lack of research causes these dangers to be quantified with difficulty. The main concerns in Australia pertain to water contamination and aquifer contamination, human health impacts, adverse effects on farming land, and very few considered impact on the economy as important (Grudnoff,

2014; Healy, 2012). The fracking chemicals added to water has been found, by the national toxics network in Australia, to cause cancer, skin and eye irritation, respiratory problems, nervous system damage, blood cell damage, endocrine disruption, and reproductive problems (Grudnoff, 2014; Healy, 2012; Moss *et al.*, 2013). Water and aquifer contamination chances are higher if non-extracted fracking fluids, left in the ground after a well has been abandoned, are improperly managed (Grudnoff, 2014; Moss *et al.*, 2013). Contamination of water leads to environmental and health impacts since water is important for food production (Grudnoff, 2014; Moss *et al.*, 2013). The most substantial risk is therefore considered to be flowback from the fracking process and mismanagement of this waste (Grudnoff, 2014; Healy, 2012; Moss *et al.*, 2013).

The Victorian government only indicated concerns during 2012 concerning effects of fracking on Australian environment and water supplies. This led to the introduction of a moratorium on fracking of rocks which released coal seam gas. This moratorium introduced two kilometre exclusion zones surrounding residential areas and also banned fracking extraction in the Sydney water catchment areas. The ban was implemented due to fears that extraction might contaminate Sydney's drinking water (Grudnoff, 2014). Preceding this moratorium, the Australian government established environmental legislation through the use of the Environment Protection and Biodiversity Conservation Act of 1999. The purpose of this legal framework was to protect and manage impacts on matters which are of national environmental significance, such as fracking. This included water resources in relation to coal seam gas and large coal mining development (Jong & Jenkins, 2014). At the end of 2010 the Legislation Amendment Act of 2010, was introduced to address issues concerning impacts on groundwater resources due to coal seam gas water extraction by petroleum tenure holders (Jong & Jenkins, 2014). Additional to this the Council of Australian Governments' Standing Council on Energy and Resources published a national regulatory framework in 2013 which covered the coal seam gas industry (Jong & Jenkins, 2014).

Amendments were clearly made in the above mentioned case studies to address environmental, groundwater and health concerns of citizens in the regions where fracking was implemented. These amendments lead one to need a deeper understanding of South Africa's current Disaster Management plans and frameworks to understand how the current DMA is able to regulate fracking (Golder Associates, 2011; SA NDMF, 2005). The next sections contextualise the DMA of South Africa to ensure an understanding of what the DMA requires and its guidelines.

2.4 South African Disaster Management Act (DMA)

South Africa has not mined in the Nama Karoo and neither has fracking been implemented within South Africa. Since fracking will be at deeper subterranean levels, there is increased potential for contamination of the environment. This environment is an environment that almost all inhabitants of the region depend

on for their lives and livelihoods. In this context it is important to consider whether or not current disaster management laws and frameworks make adequate provision for addressing fracking risks (SA NDMF, 2005; Van Niekerk, 2005). The review of current disaster management laws are necessary, considering achieving reductions in the environmental impact of fracking could necessitate the need for fracking's own set of disaster management plans and frameworks within various government departments (Golder Associates, 2011). As a point of departure it is necessary to consider the prescripts of the DMA.

On 15 January 2003, the DMA (South Africa Act 57 of 2002) was established with the specific purpose to initiate disaster risk management reform by government (SA NDMF, 2005). The DMA provides for: *an integrated and co-ordinated disaster risk management policy which focuses on the prevention or reduction of disasters, mitigation of disaster severity, preparedness, rapid and effective response to disasters, along with post-disaster recovery*. Additionally, the DMA also elaborates on establishing national, provincial and municipal disaster management structures and establishment of disaster risk management volunteer structures, all of which support efforts in fostering the coordinated approach to disaster risk management alluded to above (SA NDMF, 2005).

The purpose of the DMA is to avoid and reduce disaster losses through concerted energies and efforts made by all spheres of government, civil society, and the private sector. Furthermore, it acknowledges the crucial need for uniformity in the approach which is taken by diverse role players and partners of disaster management (Disaster Management Amended Act 57 of 2002, 2015). The DMA provides a coherent, transparent, and inclusive policy on disaster management which is deemed appropriate for South Africa as a whole (*section 7(1)*). The following sub-sections of the DMA highlights important issues relating to the management of fracking risk in the Nama Karoo. From a cursory review of the DMA the following broad issues have a bearing on the study. These include sections relating to institutional arrangements, disaster risk assessment, disaster management planning, and disaster risk reduction.

2.4.1 Disaster Management Act: Institutional Structures for Disaster Risk Management (ICDM)

As stated in the act outline, one of the main concerns of the DMA is to facilitate a coordinated approach to disaster risk management in South Africa. Facilitating this coordinated approach amongst a wide variety of role players is a key foundational step to establish institutional arrangements for Disaster Risk Management (DRM). These structures are necessary since they provide direction to DRM (in the shape of frameworks) and also provide consultative platforms to manage risk in a holistic manner. Some prominent structures to note in the case of this study include the ICDM, Disaster Management Advisory Forum(s) (DMAF) and disaster management frameworks.

The ICDM is predominantly an intergovernmental committee on disaster management consisting of cabinet members involved in disaster management or administration of legislation (see *section 4(1)(a-c)*), MEC's of each province involved in disaster management and also members of municipal councils which have been selected by the South African Local Government Association. The ICDM has two major functions as per the act that has a bearing on the study. Firstly, as per *section 4(3)(a)* the ICDM has to ensure that principles of cooperative governance for disaster risk management is related between all three spheres. Crucially, the act, in *section 4(3)(c)(i),* also grants this forum the role to advise cabinet on prominent disaster risk management issues. Thereby giving a direct link between lower levels of government and the executive authority, in the form of cabinet (Van Niekerk, 2005). Therefore the ICDM includes representatives from all three spheres of government (National, Provincial and Local Government). The existence of this forum allows local municipalities involved in this study to represent their fracking risk related concerns to the highest level of political authority in the country. In turn this could facilitate greater human, financial and political support for efforts to reduce possible fracking risks.

The Act also emphasises (*sections 5, 37* and *51)* the establishment of DMAF consisting of a multi-disciplinary stakeholder platform in which national, provincial and local government, as well as other disaster management role-players, consult with one another and coordinate their actions on matters which relate to disaster management. The purpose of the forums is to bring diverse sets of role-players into contact with one another to consult on the activity of disaster risk management. This forum would be extremely important in the case of fracking in the Nama Karoo, since there are multiple role-players that have either indicated concerns with the fracking process, or believe they have a role to play in reducing fracking risks. Some key stakeholders would include: community groups, farmers, fracking companies, town councils, and national and provincial line departments (e.g. Department of Water Affairs (DWA)).

Disaster management frameworks are crucial to institutional disaster risk management at all levels of guidance. In the broadest sense, frameworks give guidance to how all disaster management activities should be implemented at all three spheres of government. The establishment of frameworks are highlighted in *sections 6, 28, and 42*. However, the exact content of a disaster management framework is only directly discussed under *section 7* of the DMA. Although *section 7* refers to the content of the national disaster management framework, *sub-sections 7(d) and 7(e)* argues that the content and structure of the national framework should be mirrored by provincial and local levels of government. Crucial components of a framework that have to be considered when formulating a framework to address the fracking risk would include:

- *Section 7(d)(ii)* allocating specific roles and responsibilities to different spheres of government (in managing or reducing a specific risk);
- *Section 7(2)(b)* establish prevention and mitigation as the core principles of disaster management
- *Section 7(2)(f)* facilitate-

(i) the involvement of the private sector, non-governmental organisations, traditional leaders, technical experts and volunteers in disaster management;

(ii) community participation in disaster management; and

(iii) partnerships for purposes of subparagraphs (i) and (ii) between organs of state and the private sector non-governmental organisations and communities;

- *Section 7(2)(g)* facilitate disaster management capacity building training and educationincluding in schools, and provide incentives for such capacity building, training and education;
- *Section 7(2)(h)* promote disaster research;
- *Section 7(2)(i)* guide the development of a comprehensive information management system;
- *Section 7(2)(l)*address the requirements for co-operation and co-ordination between the different spheres of government, the privatesector, on-governmental organisations and communities; and
- *Section 7(2)(m)* provide key performance indicators in respect of the various aspects of disaster management.

All afore mentioned institutional structures would first have to be established or formulated, before practical risk management activities such as disaster risk assessment or disaster risk reduction can be initiated.

As fracking has not been conducted in South Africa before and the Nama Karoo is classified as a fragile ecosystem, this study has to establish the extent of risks posed by fracking to environment and people who depend on it for their lives and livelihoods. A crucial step in determining the extent of a disaster risk is the process of disaster risk assessment. In this context it is crucial to take note of the rational and purposes behind disaster risk assessment as alluded to in the South African Disaster Management Act.

2.4.2 Disaster Management Act: Assessment of risk

In *section 1* of the DMA the term 'risk assessment' is defined as *"a methodology to determine the nature and extent of risk by analysing potential hazards and evaluating existing conditions of vulnerability that together could potentially harm exposed people, property, services, livelihoods and the environment on which they depend"* (Disaster Management Amended Act 57 of 2002, 2015). The purpose of risk assessment is to establish potential magnitude and severity of a disaster. The need for risk assessment is crucial within the context of this study, considering the extent of possible risks to communities and their livelihoods due to fracking not being fully understood.

Section 20, 33, and 47 of the DMA highlights the need for risk assessment to be done at all levels of government and within the private sector. *Section 20 and 33(1)(a)* highlights that the national disaster management centre needs to give guidance on several key activities related to risk assessment organs of

state, private sector, non-governmental organisations, communities and individuals. These activities include determining levels of risk, assessing community and household vulnerability to disasters which may occur, increasing capacity of communities and households to minimise risk and impact of disasters which may occur along with monitoring disaster likelihood of occurence. *Section 20 and 33(1)(a)* therefore indicates that the national disaster management centre needs to aid in promoting risk assessment amongst various stakeholders, especially in instances where a risk is of national importance (i.e. fracking).

As the study focuses mostly on the local municipal level, it is important to consider the acts prescripts relating to risk assessment on the local municipal level. *Section 47(1)(a)* indicates that the municipal disaster management centre also needs to give guidance to organs of state, the private sector, non-governmental organisations, communities and individuals in the municipal area to assess and prevent or reduce risk of disasters which includes ways and means of: determining levels of risk, assessing vulnerability of communities and households to disasters, increasing capacity of communities and households to minimise risk and impact of disasters that may occur and also monitoring the likelihood of disasters that may occur. *Section 47(1)(c, d)* also indicates that municipalities need to integrate prevention and mitigation methods through development plans, programmes and initiatives, and they also need to manage high-risk developments such as fracking.

One of the focus areas of this study is to ascertain what basic risks have been assessed by the communities and local governments relating to the development of fracking in the Nama Karoo. The various communities are expected to have some knowledge relevant to fracking and its processes. This knowledge then leads them to draw their own conclusions as to their community, livelihood and property vulnerabilities, and risks if fracking development in the Nama Karoo does commence. The DMA guidelines for risk assessment also emphasises the need for comprehensive disaster management planning. The following section highlights important aspects of disaster management planning as per the DMA.

2.4.3 Disaster Management Act planning

The results of disaster risk assessment need to be reformulated into disaster management plans. The DMA *section 25(a)(i), 38, 43, 52,* and *53,* requires that roles and responsibilities are defined in terms of the disaster management framework which also includes the roles and responsibilities for certain disaster risk management activities (including response, post disaster recovery, rehabilitation and risk assessment). *Section 25(a)(i-vi)* reiterates that a disaster management plan needs to establish the way in which concepts and principles of disaster management are to be applied within its functional area, roles and responsibilities in terms of the disaster management framework, roles and responsibilities regarding

emergency response and post-disaster recovery and rehabilitation, particulars of its disaster management strategies, and also contingency strategies and emergency procedures in the event of a disaster occurring. This includes measures to finance these strategies (Disaster Management Amended Act 57 of 2002, 2015). Figure 2.1 below illustrates a comprehensive diagram of the three levels of planning after which the DMA planning procedures is discussed.

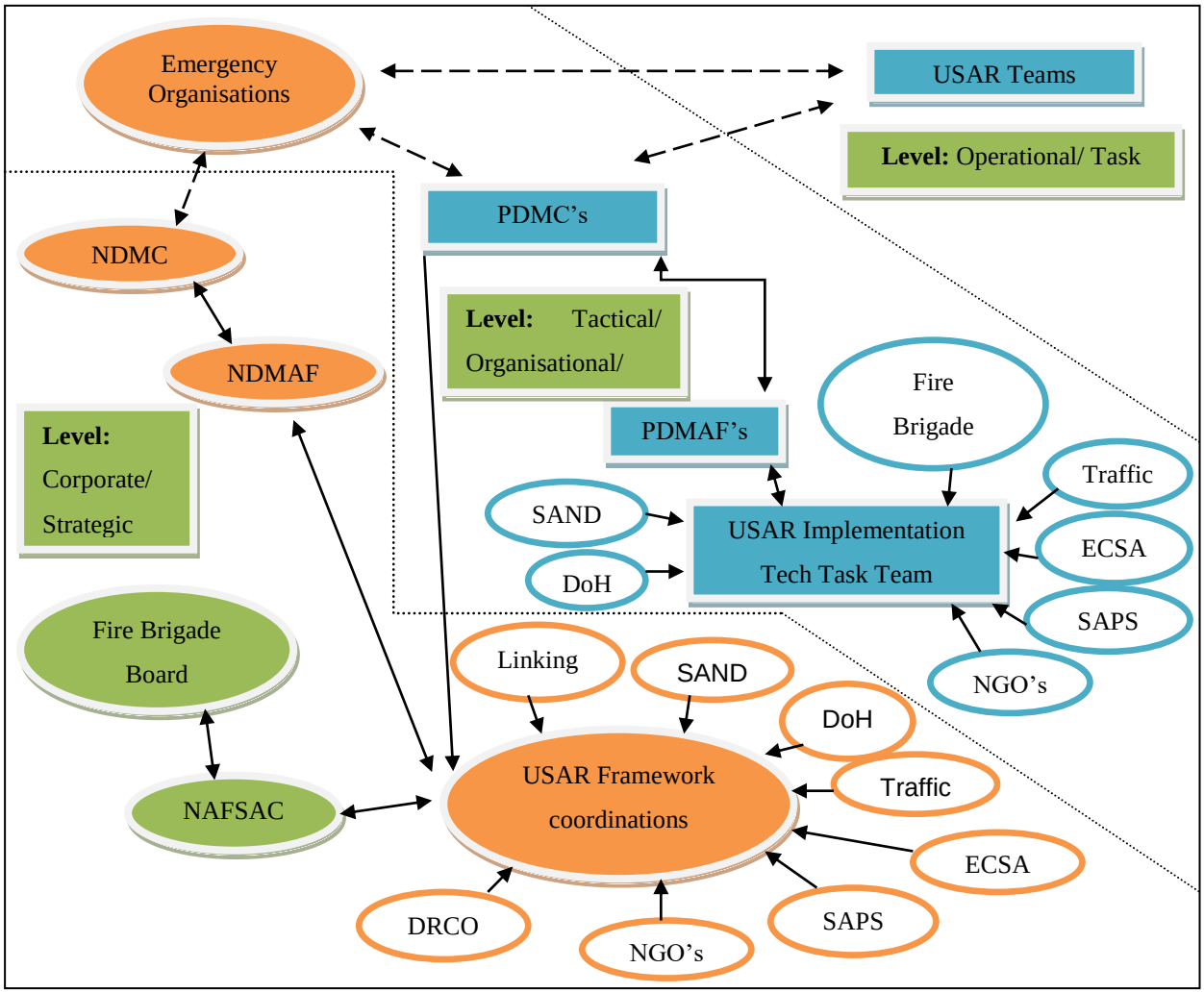


Figure 2.1: The coordination between the three levels of disaster management plan development (Disaster Management Legislation Policy and Compliance Management, 2014).

These various sections of the legislative framework are relevant to the study since fracking could pose a serious disaster risk to communities in the Nama Karoo and their livelihoods. The roles and responsibilities referred to in Figure 2.1 above will fall to local governments in the Nama Karoo while the NDMC provides guidance to local municipalities for disaster management planning. It should be noted that emphasis is placed on roles and responsibilities for emergency response and post-disaster recovery and rehabilitation (Disaster Management Amended Act 57 of 2002, 2015). If the disaster assessments and risk assessments are not done properly, by the NDMC and local municipalities of the Nama Karoo, during the initiation phases of fracking development, emergency response and post-disaster recovery and rehabilitation plans will not be in place or enforceable when needed after fracking has commenced or a fracking related disaster happens to occur. The roles and responsibilities are therefore important to ensure that stakeholders and role-players know what is expected from them and that proper assessments are done in accordance with the DMA. Since local government has most of the responsibility concerning disaster management, the provincial and national structures serve as a supporting role. Before local governments can address fracking risks and management of fracking risks, the risks coupled with fracking need to be identified in provincial and national structures as feasible additions to the current disaster management

plans and frameworks. It is therefore imperative that local government draws up fracking risk plans and risk assessments for provincial and national structures to approve and acknowledge (Disaster Management Legislation Policy and Compliance Management, 2014).

The Disaster Management planning is directly linked to disaster risk reduction. Thus only after plans have been formulated for specific risks (e.g. fracking) can concrete strategies be formulated to appropriately reduce risks. Consequently, it is important to review legal aspects relating to risk reduction as per the DMA.

2.4.4 Disaster Risk Reduction

The DMA *section 1* defines 'disaster risk reduction' as *"either a policy goal or objective, and the strategic and instrumental measure employed for anticipating future disaster risk, reducing existing exposure, hazard or vulnerability and improving resilience"* (Disaster Management Amended Act 57 of 2002, 2015). Therefore, disaster risk reduction efforts can be considered to be medium- to long-term multi-sectored efforts which are focused on vulnerability reduction.

Sections of the Act that guides disaster risk reduction activities are discussed under the principles of Prevention and Mitigation in *sections 20(1)(b-d), 33(1)(b-d) and 47(1)(b-d).* In all instances under *sub-section 20, 33, and 47(1)(b),* all levels of government are required to develop and implement appropriate prevention and management methodologies within their jurisdiction. *Sections 20, 33, and 47(1)(c)* recognises the need for risk reduction efforts to be integrated into ongoing Integrated Development Plans (IDP) projects, processes, programmes and structures (SA NDMF, 2005). This sub-section is especially relevant to the fracking situation in the Nama Karoo. Since fracking would mostly likely be linked to future economic development projects in the region (and therefore be a crucial part of IDP planning), an opportunity exists to apply disaster risk reduction strategies to any proposed fracking projects. *Sections 20, 33, and 47(1)(d)* also places onus on all levels of government to develop risk reduction strategies and partnerships to manage any "high risk developments". The emphasis on high risk developments in the DMA recognises that some development efforts might have socio-economic benefits, although associated consequences can manifest, which negates said benefits. This aspect of the Act almost perfectly describes issues of fracking in the Nama Karoo, where the possible economic windfalls are emphasised by officials and some community members, although there is also recognition that longer term environmental, economic and social vulnerabilities might prove disastrous for the area.

Sections 25(1)(a)(v), 38(1)(a)(v), and 52(1)(a)(v) refers to integrating disaster risk reduction into the disaster management planning. As such all levels of government should outline the particulars of disaster risk management strategies that they intend to implement. These risk reduction strategies should also be updated along with the disaster management updates (*according to sections 25(1)(c), 38(1)(c) and*

52(1)(c)). From these sub-sections the DMA places a strict responsibility on all levels of government to make disaster risk reduction a priority in managing not only disaster risk but also large social development initiatives.

The Act above gives a broad legal basis for the activity of disaster risk management. However, to give an operational aspect to legislation, the SA NDMF was developed. The SA NDMF and its KPAs and Enablers are discussed, as they pertain to this study.

2.5 National Disaster Management Framework

The SA NDMF acts as the legal instrument, specified and supported by the DMA, to address the need for consistency across multiple disaster management stakeholder groups (Disaster Management Amended Act 57 of 2002, 2015). Considering this context the SA NDMF also recognises a diversity of risks and disasters which occur in South Africa while prioritising developmental measures aimed to reduce vulnerability of disaster-prone areas, communities and households. The SA NDMF places an explicit emphasis on disaster risk reduction concepts of disaster prevention and mitigation which is viewed as the core principles which guide disaster risk management in South Africa (Disaster Management Amended Act 57 of 2002, 2015). Furthermore the SA NDMF also informs the resulting development of provincial and municipal disaster management plans and frameworks. These frameworks and plans are required to guide action in all spheres of government (Disaster Management Amended Act 57 of 2002, 2015). The framework consists of four key performance areas (referred to as KPAs) and three supportive enablers required to achieve the objectives set out in the KPAs. The KPAs and Enablers follow specified objectives and, as required by the DMA, key performance indicators (KPIs) to further guide and monitor progress (SA NDMF, 2005).

Broadly, the SA NDMF component can be outlined as follows (SA NDMF, 2005): KPA 1 describes internal disaster management arrangements, processes and mechanisms which aid in establishing co-operative governance for Disaster Risk Reduction (DRR). KPA 2 outlines the requirements for implementing disaster risk assessment and monitoring by the various organs of state within all spheres of government. KPA 3 focuses on requirements for aligning disaster management frameworks and planning within all spheres of government. Lastly, KPA 4 describes the measures which ensure effective disaster response, recovery and rehabilitation planning (SA NDMF, 2005). These KPAs cannot stand alone since they represent an ideal and are not enforceable without uniderlying Enabler support.

Enabler 1 focuses on priorities related to establishing an integrated and comprehensive information management and communication system for disaster risk management. It also addresses information and communication requirements of each KPA and establishes integrated communication links within KPAs

and Enablers. Enabler 2 addresses disaster risk management priorities within education, training, public awareness and research. It further focuses on mechanisms for development of education and training programmes for disaster risk management and associated professions which further incorporate relevant aspects of disaster risk management in various levels of schools and training centers. Its main focus, though, is to strengthen public awareness and risk avoidance behaviour. Enabler 3 sets out the mechanisms for funding of disaster risk management in South Africa (SA NDMF, 2005).

A more specific discussion on the KPAs and Enablers is necessary. However, only the most relevant KPAs and Enablers to managing the disaster risk for future fracking procedures are discussed, since this is in line with the focus of this study. Section 2.5.1 discusses KPA 1since it has relevance to this study.

2.5.1 KPA 1: Institutional Arrangement for DRM

The first KPA focuses on establishing the necessary institutional arrangements for implementing disaster risk management in national, provincial and municipal spheres of government. This KPA is specifically formulated with the intention of furthering co-operative governance principles for disaster risk management purposes. The emphasis is therefore on establishing structures or governance frameworks that ensures involvement of all stakeholders in national, provincial and municipal spheres in disaster risk management (SA NDMF, 2005). This KPA therefore aids in establishing a chain of command along with associated roles and responsibilities within Disaster Management structures.

A plethora of institutional arrangements for DRM is identified by the SA NDMF. Some of these structures might not be applicable to managing a certain risk. Therefore, the first steps in establishing an institutional arrangement for DRM is, usually, to conduct a cursory review of disaster risk in the municipality. Once the risk landscape is better understood, appropriate institutional arrangements can be selected to address the risks. So in the case of fracking two structures can, for instance, be established. Firstly, an ICDM, this structure addresses the cross border, multi-jurisdictional, nature of the fracking risk and could bring together officials from all affected towns, provincial and national departmental representatives, academia, informed community members and fracking companies. The second structure, the DMAF, can function on the local municipal level (relative to each affected town), and bring together government officials, civil society organisations, fracking companies, organised business, informed community members and academia. Although the establishment and composition of structures is largely the responsibility of local municipality they are not precluded from asking national and provincial governments concerning their inputs and suggestions on possible participants that could add value to said structures.

This KPA is directly relevant to managing fracking risks in the Nama-Karoo. Fracking in the region is essentially a trans-boundary issue that affects different levels of government jurisdiction. This would

imply that a diverse set of role players would need to be consulted and involved in ensuring that fracking risks are reduced. The multiple stakeholder involvement could be facilitated through one of the forums suggested by the KPA, such as a DMAF. The following Section 2.5.2 focuses on the risk assessment KPA. KPA 2 is a result of correspondence between role-players within a DMAF platform.

2.5.2 KPA 2: Disaster Risk Assessment

The second KPA focuses on the need for disaster risk assessment and monitoring which sets priorities, guides risk reduction action and monitors efficiency of disaster management efforts. This KPA proceeds to outline requirements and procedures for implementing disaster risk assessment and monitoring by spheres of government (SA NDMF, 2005). Firstly risk assessment needs to determine the level of risk by identifying and analysing potential hazards and/or threats, assess conditions of vulnerability, to determine the level of risk for different situations and conditions, and lastly setting priorities for action (SA NDMF, 2005). The focus is on setting priorities addressing disaster risk reduction priorities and updating the disaster risk assessment information. Identifying changing patterns and new developments in the risk profiles aid disaster management planning processes (SA NDMF, 2005). Since fracking in the Nama Karoo is so new and the human livelihoods and environment is considered fragile, the full extents of risks associated with fracking are not known yet. This KPA therefore provides a tool which should allow a more holistic view to be created and gained of the current situation surrounding fracking in the Nama Karoo. Further focus on disaster risk reduction is discussed under KPA 3 in Section 2.5.3 since KPA 2 risk assessments indicate toward the need for minimising effects of identified risks.

2.5.3 KPA 3: Disaster Risk Reduction

The third KPA introduces disaster risk management planning and implementation of said plans. Its purpose is to inspire developmentally orientated approaches, plans, programmes and projects that would reduce disaster risks. It also addresses requirements for alignment between disaster management frameworks and development planning within all spheres of government. Furthermore it focuses attention on planning and integration of core risk reduction principles, prevention and mitigation of ongoing programmes and initiatives (SA NDMF, 2005). This means that disaster risk reduction needs to be incorporated into a developmental project, such as fracking in the Nama Karoo. Consequently all fracking related planning in the area should integrate core risk reduction principles of prevention and mitigation of the ongoing initiatives concerning fracking process risks.

The risk reduction principles differ between the levels of disaster management plans. A level one disaster management plan establishes foundational institutional arrangements for disaster risk management and

compile contingency plans for responding to identified priority threats, which were identified during initial stages of the disaster risk assessment. Identification of these institutional arrangements and priorities enable development of a level two disaster management plan. Level two disaster management plans establish necessary supportive capability processes for comprehensive disaster risk assessment, establish formal consultative mechanisms to develop disaster risk reduction projects, and introduce supportive information management and communication systems relevant to disaster risk reduction. Level three disaster management plans require that plans specify clear institutional arrangements for co-ordinating and aligning the disaster management plan with other governmental initiatives, and the plans structured by institutional role players. Level three disaster management plans thus requires evidence of informed disaster risk assessment and ongoing disaster risk monitoring capabilities along with relevant developmental measures, reducing vulnerability of disaster-prone areas, communities and households. It is imperative that the Nama Karoo local governments advance through three disaster management plan levels in unison to enable effective disaster risk reduction coupled with fracking practices. This uniform progression through the disaster management plan levels enables local governments to address the adverse effects of fracking uniformly.

This context is of importance concerning environmental impacts fracking can have, which depend largely on the extraction plan logistics along with drilling operations management at the fracking plant (Healy, 2012). This extraction plan is therefore needed to compile more accurate disaster management planning. This plan is not available in South Africa at this stage, since exploration still needs to be done (Brady, 2011; Healy, 2012). Considering the discussions on KPA 1-3 in Sections 2.5.1 – 2.5.3, it is deemed necessary to contextualise the relevant Enablers coupled with this study. It should be noted that KPA 4 is not discussed in the context of this study since it pertains to reactive aspects of disaster management. In the case of fracking, risks have to be pro-actively reduced, hence the focus on the first three KPAs. Enabler 1 is subsequently discussed since it pertains to KPA 1, 2 and 3 which has been discussed in Sections 2.5.1, 2.5.2 and 2.5.3.

2.5.4 Enabler 1: Information management and communication

Enabler 1 is aimed at guiding development of comprehensive information management and communication systems which aims to establish integrated communication links with all the disaster risk management role players (SA NDMF, 2005). Furthermore, it addresses information and communication requirements of all the KPAs, and Enablers 2 and 3. Enabler 1 emphasises the need to establish integrated communication links with all the disaster risk management role players in national, provincial and municipal spheres of government (SA NDMF, 2005). The relevance of Enabler 1 to this study is that government, communities and fracking companies need to communicate concerning possible disaster risks associated with fracking processes. This communication between external role players,

communities and fracking companies, leads to an improved exchange of information between all parties on hazards and vulnerabilities, which communities can face due to fracking processes. The communication between these parties contributes to formulation of more comprehensive disaster management plans as well as contributing to implementation of said plans in the Nama Karoo. Enabler 2 establishes requirements for education and information distribution concerning disaster management.

2.5.5 Enabler 2: Education, training, public awareness and research

Enabler 2 focuses on promoting a culture of risk avoidance among stakeholders by building capacity in role players through integrated education, training and public awareness programmes informed by scientific research (SA NDMF, 2005). It addresses requirements to promote and support a broad-based public awareness and responsibility campaign of risk avoidance. Furthermore it also discusses priorities and mechanisms for support and development of coherent and collaborative disaster risk research agendas (SA NDMF, 2005). The relevance of Enabler 2 to fracking is that fracking is in the development stages within South Africa. South Africa can, therefore, learn from mistakes that were made in Texas and Australia (Sections 2.2 and 2.3), amongst others. This view is directly in line with risk avoidance strategies (guidelines discussed in Section 2.5.3). DMAF set-up, as per Section 2.5.1, would be the ideal mechanism to promote public awareness and research components of this enabler. Education and public awareness concerning fracking in the Nama Karoo, leads to several benefits for affected communities including, improved community and government capacity to reduce fracking risk, improved disaster response mechanisms and greater efficiency in implementing contingency planning (as all stakeholder would understand their roles). These contributions would therefore aid the overall goal of reducing risks related to fracking.

2.6 Conclusion

The aim of Chapter 2 was to give an overview of knowledge which is currently available concerning fracking procedures, specifically applicable to the Nama Karoo in South Africa. The rational for fracking in South Africa in Section 2.1.1 explains why fracking is proposed for the Nama Karoo in South Africa and the needs fracking could address for South African government. The overview of fracking in Section 2.1.2 adds to existing knowledge compiled in Sections 1.1.1 and 1.1.2 of Chapter 1. The coupled environmental impacts of fracking in Section 2.1.3 describes which chemicals used during the fracking process could have adverse effects on the environment and how adverse these effects could be. Hydraulic fracturing and fragile ecosystems – the case of Texas in Section 2.2 contextualises the problems fracking caused in Texas USA. Hydraulic fracturing and fragile ecosystems – the case of Australia in Section 2.3 contextualises the problems fracking caused in Australia. The South African Disaster Management Act in

Section 2.4 addresses the various aspects of the DMA relevant to this study. Section 2.4 contextualising the DMA is divided into four sub-sections; DMA: Institutional Structures, DMA: Assessment of Risk, DMA planning, and Disaster Risk Reduction. These sections further contextualise the DMA and what is expected from government by the DMA. The National Disaster Management Framework in Section 2.5 discusses the framework which is the result of the DMA and the need for implementation guidelines. This need for implementation guidelines is addressed by KPA 1: Institutional Arrangement for DRM, KPA 2: Disaster Risk Assessment, KPA 3: Disaster Risk Reduction, Enabler 1: Information management and communication, Enabler 2: Education, training, public awareness and research. These various guidelines are discussed since they are relevant to this study and its data analysis which follows.

CHAPTER 3 DATA ANALYSIS

3.1 Introduction

Preceding this chapter the Disaster Management plans and frameworks applicable to South Africa was contextualised. This contextualisation created an understanding of applicable laws and frameworks associated with the DMA that could be applicable in managing disaster risks related to fracking. The current fracking knowledge, challenges and environmental concerns were discussed, based on the research objectives stated in Chapter 1 Sections 1.3 and 1.4. This research specifically focuses on the risk of disaster due to proposed fracking in fragile ecosystems. The Nama Karoo is classified as a fragile ecosystem and this is the area where fracking is proposed. The Nama Karoo is a very large area which reaches over the Western Cape, Eastern Cape and Northern Cape. This wide area led to the decision to organise interviews with different towns in the different provinces to see what their perspectives are, and to indirectly establish if DRM principles are being followed and considered as important.

The contextualisation of the DMA and SA NDMF is done in Chapter 2 Sections 2.4 and 2.5 of this document. The participants of the research study were indirectly asked to relay their knowledge concerning the current management of primary disaster risks associated with fracking (environmental and groundwater protection, and pollution) in their area. The sole focus of this study does not directly focus on DRM and therefore DRM questions were not asked directly. The interview questions focused on fracking, since communities in the Nama Karoo indicated the need for a study concerning fracking. During the progression of the study it was ascertained that fracking is directly linked with community risks and risks to livelihood structures within the Nama Karoo. Disaster risks are therefore associated with fracking, which is an underlying issue, addressed more readily without respondents realising disaster risks are being addressed. The responses gained during the study also indicated towards disaster risk management gaps which are critically important to this study. It was imperative to establish exactly what the local government officials and organised community groups know and what type of knowledge they do possess in case of disastrous situations and management thereof. The various towns were also approached to assess their knowledge of fracking. The parameters were followed as stipulated in Chapter 1 Section 1.6, and Chapter 2 Sections 2.4 and 2.5 of this document. Based on these parameters the research was conducted in the following towns, indicated in Figure 1.5: Beaufort West, Britstown, Carnarvon, Colesberg, Graaff Reinet and Victoria West. Section 3.1.1 provides a brief overview of the methodology followed during this research study. The information presented is directly linked to the information presented in Section 1.6 of Chapter 1.

3.1.1 Brief overview of methodology

In Section 1.6 of Chapter 1, the methodology is explained at length. In short, the methodology states that organised community groups and local government officials from selected towns within the Nama Karoo were invited to take part in this research study. The methodology is divided into the literature review and empirical study. The empirical study is further divided into the research setting and sampling, data collection, data analysis and ethical considerations. The data sampling areas, indicated in Figure 1.3, are Beaufort West, Britstown, Carnarvon, Colesberg, Graaff Reinet and Victoria West. The empirical methodology is used since the topic under investigation is considered as a practical and theoretical issue. Based on the study being a practical and theoretical issue, a qualitative research method is followed for obtaining data. The qualitative analysis is based on interpretation of data, derived in this case from interviews with organised community groups and local government participants. This also led to deciding on a qualitative data collection method. The advantage of a qualitative research approach is that personal opinion is captured in the form of data. This ensures a fuller picture being formed concerning the participants, local government officials, companies invested in the project and disaster management or environmental policy and management concerns.

During the participation there were eight questions asked relating to basic fracking knowledge, government communications, and therefore indirectly knowledge relevant to disaster risk, disaster management and disaster perspectives were ascertained (see Annexure A and B at the end of the study for questionnaires). The participation groups varied between four and ten participants, while the government officials were only one-to-one interviews. In some cases participants did not contribute their own opinions and only agreed with other participants in the focus group sessions, after which they were specifically asked for their own contribution and most of them then only stated that they agree with what had already been said. Some local government officials declined to answer due to conflicts of interest, procedures which were not followed, by the fracking company or their own government superiors, and, also, lack of knowledge. Victoria West's local government could not take part in the study at all, since the whole government department that needed to be interviewed were newly appointed, two months before the research was done. This was due to bureaucratic related problems, such as human resources administration, appointment of a qualified individual suited for the position and also corruption related issues. This caused them to not be able to contribute concerning the research, since they did not know anything concerning fracking or what it entailed. The Britstown local government representative communicated that he did know what fracking was, and could not take part in the study since he had not been formally informed by his superiors concerning fracking. This had ethical repercussions for this local government official and therefore he declined to take part. Victoria West and Britstown were therefore omitted from tables representing the government responses. These omissions do not affect the validity of information or research since all government bodies follow the same frameworks, legislation, policies and laws.

Each question has an explanation representing the extent of grasp each organised community focus group or government official had when answering the question and this grasp is based on how valid their information was to the question and study. Furthermore, a concept grading bar below each graph ensures that grading standards were indicated for each specific question. The concept bar allocates a knowledge number to each community focus group and government official based on their contribution. This knowledge number is then allocated to community focus groups or government official and represented in the bar graph. After each bar graph there is a short discussion stating the findings more elaborately to ensure that context and participant understanding of the question is conveyed.

All of the questions were classified according to their allocated KPA. Each KPA is discussed in Chapter 2 under the following sections; KPA 1 in Section 2.5.1, KPA 2 in Section 2.5.2, and KPA 3 in Section 2.5.3 along with Enabler 1 in Section 2.5.4 and Enabler 2 in Section 2.5.5. This classification allows for easier understanding of information relayed during interviews and also allows for parallels to be drawn between local government and organised community group questions and answers. The classification of questions under the KPAs and Enablers also immediately enable classification of questions and answers relayed during interviews with relation to the SA NDMF. The participants were either only from the organised community group or local government during the interviews. The questionnaire for government differs from the questions asked during community interviews and therefore the government and organised community group questions are attached in the annex of this document. The following tables represent local government and organised community group feedback on various questions asked concerning applicable KPA or Enabler headings with a short overview of the relevant KPA or Enabler which is discussed in Sections 2.5.1, 2.5.2, 2.5.3, 2.5.4 and 2.5.5. Firstly KPA 1 is discussed along with the relevant research questions and associated participant responses.

3.2 KPA 1: Institutional Arrangement for DRM

The performance area being addressed focuses on establishing necessary institutional arrangements for implementing DRM strategies at national, provincial and local levels of government. These structures include disaster management centres, inter-governmental, and DMAF and disaster management frameworks. Through DRM structures a chain of command is established within local government, district government, and other government levels. The local level disaster management institutions (mentioned above) are primarily responsible for carrying out disaster management activities, such as identifying and reducing risks in their community or district. These local and district level structures also requires feedback to provincial and national government, concerning disaster risk management issues that could be too substantial for them to handle using their own resources and capacity (SA NDMF, 2005). The institutional arrangements highlighted the fact that government needs to be cognisant of emerging risks in their jurisdiction. Fracking serves as an emerging risk to each town's community forum, if one

exists. Local level disaster management structures therefore need a mechanism, such as DMAF, to focus on fracking and the risk it might pose to communities in the Nama Karoo. Since fracking not only affects government spheres and disaster management planning, local businesses and the community should also participate to a greater extent in existing institutional arrangements. Local businesses and communities could contribute valued input relevant to risk reduction and contingency plans relating to fracking enabling community buy-in.

Government respondents from all the towns were asked to elaborate on existing institutional arrangements for managing fracking risk in their towns. In this context respondents referred mostly to their IDP planning procedures, water and pollution management policy, while not referring to or intentionally excluding level of their disaster management plan. Although, no direct disaster management structures were mentioned, the existence of structures could be inferred from the level outcomes of disaster plans presented below. The following table (Table 3.1) visually indicates the various disaster management plan levels, along with the required outcomes of each level. This contextualises the basis of disaster management institutional guideline for compiling a disaster management plan in accordance with the KPAs and Enablers contextualised within the SA NDMF (NDMC & Pat Reid, 2008). Thus, if a municipality indicated that they, at least, have a level one disaster management plan in place, they would need a basic disaster management structure, such as a disaster management centre. If a level two plan exists, it could indicate that more complex structures, such as DMAF or ICDM are in place, since these are crucial for a comprehensive disaster risk plan. Inferences can not be made on the function of these structures solely based on the presence or lack of plans. The government respondents from the Nama Karoo indicated the following with regard to planning in their respective municipalities.

Table 3.1: Levels of DRM plans and their associated critical outcomes (NDMC & Pat Reid, 2008).

Level of plan	**Critical outcomes**	
Level 1	1	Establish foundational institutional arrangements for disaster risk management
	2	Develop the capability to generate a Level two Disaster Risk Management Plan
	3	Develop and implement contingency plans for known priority risks
Level 2	1	Establish processes for comprehensive disaster risk assessments
	2	Identify and establish consultative mechanisms for specific priority disaster risk reduction projects.
	3	Develop a supportive information management system
	4	Develop emergency communication capabilities
Level 3	1	Establish specific institutional arrangements for coordinating and aligning disaster risk management plans
	2	Establish mechanisms to ensure informed and ongoing disaster risk assessments
	3	Institute mechanisms to ensure ongoing relevance of disaster risk management policy frameworks and plans

In Graaff Reinet their plan contains comprehensive risk assessments and risk management processes, which were coupled with hazard and risk analysis along with risk evaluation and ranking. In addition to this there are operational planning guidelines and frameworks, pertaining to contingency plans, which are in place for the various perceived risks stipulated in the risk assessment (Mayor Camdeboo Municipality,

2012). This plan therefore functions as a level two plan, which could indicate that more advanced disaster management arrangements (advisory forums or DMAF) are in place to aid in risk assessments and the formulation of contingency plans.

Disaster management plans in Britstown and Carnarvon comprise of prioritised items that have been identified concerning potential hazards and risks along with suggested projects to address these items. Both towns would therefore have a level one disaster management plan in place. This would imply that some structures are in place (likely a disaster management centre), although the capacity has not yet been developed through other forums to carry out more advanced disaster risk management duties, such as comprehensive risk assessments. Respondents from Carnarvon and Britstown also indicated that their current disaster management planning is not considered a focal area by decision makers in the municipality and integrated development plans are often used to address risk instead of disaster management plans (Eckard, 2015).

Colesberg does not have a disaster management plan, only an integrated development plan. The disaster management sector is therefore addressed as a sub-section of the integrated development plan for the Colesberg community (Department of Rural Development and Land Reform, 2016). Although the SA NDMF calls for integration of disaster management plans with IDPs on planning level three, it seems that Colesberg has omitted the level one and two planning procedures informing this integration. Therefore, the case could be that only a basic structure, such as a disaster management centre exists, which then ensures compliance with some aspects of the SA NDMF. However capacity could be limited to create structures such as DMAF.

A comprehensive disaster management plan was also not found in the case of Beaufort West. The local government disaster management representative from Beaufort West, however, did indicate that a reporting structure is in place for reporting disaster management practices to provincial government (Central Karoo District, 2015). Although absence of comprehensive disaster risk management planning is present in the area, it seems that steps have been initiated to add basic disaster management structures, in the shape of a cooperative institutional mechanism, with provincial disaster management. The respondent from Beaufort West also alluded to a strategy for disaster management that has been integrated into the IDP of the municipality. This strategy specifically outlines their various disaster management objectives and how they plan on reaching these objectives.

Victoria West has compiled a comprehensive disaster management plan with various disaster management sub-sections. The sub-sections within the disaster management document addresses preparedness for disasters, disaster analysis, reaction to disasters, and emergency occurrence plans. This disaster management plan adheres to the critical outcomes of a level one and two disaster management plan (Ubuntu Local Municipality, 2015). The comprehensive nature of planning done in Victoria West

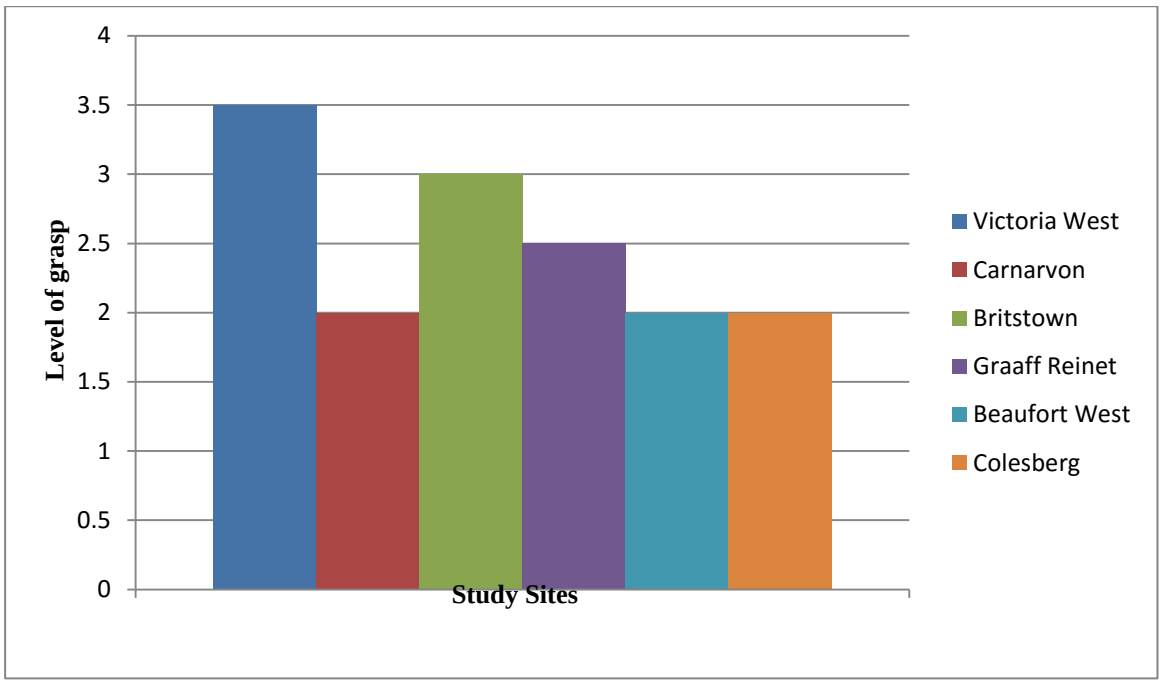
could indicate the existence of more advanced institutional arrangements for disaster risk management in the municipality.

Very few municipalities in the Nama Karoo could have advanced structures for DRM considering the current state of their DRM plans. Mostly municipalities have conducted level one planning procedures and then made recommendations regarding integration into IDP procedures. However, level two and three planning procedures were largely absent. This is a concern, since these levels of plans allow for comprehensive assessment and formulation of targeted strategies to reduce risk.

In the absence of DMAF it is important to ascertain what various groups in communities know and understand regarding fracking. The participants were encouraged to explain what fracking associated advantages were and why they highlighted these fracking aspects as advantages of fracking. This questions' main aim is therefore the function of a proxy indicator for issues concerning fracking, which a DMAF would have to address, if there were a DMAF.

3.2.1 Community opinion on advantages of fracking

This question can be found in the community questions annexture as question five. The table below presents the parameters of question data analysis which is then presented below in a bar graph format for each of the participating towns.



No grasp of concept - No advantages or reason is given. Knowledge number = 1

Average grasp of concept - Gives an advantage without a reason. Knowledge number = 2

Good grasp of concept - Gives a few advantages with a reason. Knowledge number = 3

Excellent grasp of concept - Gives a few advantages and a few reasons. Knowledge number = 4

Figure 3.1: The community focus group perceived advantages to fracking by community focus groups.

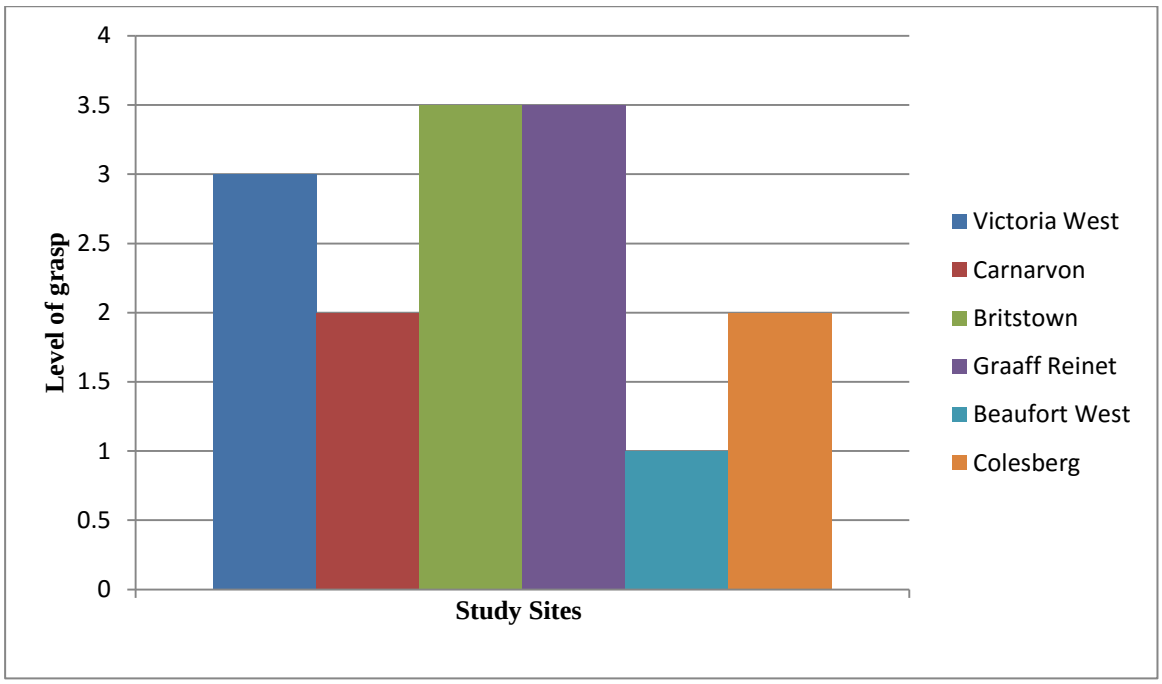
Figure 3.1 indicates that some respondents from Britstown, Carnarvon and Graaff Reinet could not see any advantages to fracking. They stated this outright in the interviews and felt that it was a waste to try and see any advantages to the prospected fracking situation. Other respondents from Beaufort West, Britstown and Colesberg gave an advantage during the respective interviews, without any supporting reasons. Some of the Britstown respondents indicated that a monetary injection into their community and resultant job creation, would aid the community since their community is poor. Respondents from Beaufort West stated that if groundwater were contaminated, not even the prospect of increased and cheaper energy sources, in the form of shale gas could make up for the damage. Respondents from Colesberg refused to believe that fracking would come to their area so they did not see the need to worry about the issue at this stage. Respondents from Graaff Reinet and Victoria West had participants who indicated a few advantages with supporting reasons. Specifically, respondents from Victoria West also mentioned that the town would benefit from an increase in capital flow and job creation within the town. Victoria West also indicated that the rest of the country would benefit more from fracking than just their community per se. Respondents from Graaff Reinet felt that fracking would aid the poorer community to gain access to employment opportunities and higher pay grades. All of the communities indicated their concerns for water and groundwater contamination and management thereof, along with monetary implications for their various community members. The community participants saw, for the most part, only short term benefits coupled with very limited long term advantages to fracking.

The diverse set of views indicated during interviews, compiles very specific challenges concerning how institutional arrangements for DRM are set up to manage fracking risk. Specifically, DMAF would have to include participants from both the pro-fracking lobby (those that see advantages) and anti-fracking lobby. This composition, within DMAF, is needed as a means to find a balance between the perceived benefits of fracking (socio-economic, generating employment opportunities and energy resource exploitation) and perceived negative impacts (environment and groundwater pollution). Both sets of views would be crucial if holistic and uniform disaster management, and contingency plans are created.

It was also imperative to understand how communities view their role in disaster management and how they believe they could take steps to minimise impacts fracking could have on their environment. This view is established through the second question relevant to KPA 1 presented below. This question aims to establish what role community based stakeholder groups (including businesses) could play in disaster risk reduction and which strategies are in place concerning fracking currently. These roles and strategies could be presented to the DMAF subcommittee on fracking for consideration, if such a committee is established.

3.2.2 Community opinion on measures minimising environmental impacts of fracking

This question can be found in the community questions annexture as question four. The table below presents the parameters of the question data analysis which is then presented in a bar graph format for each of the participating towns.



No grasp of concept - Gives no measures. Knowledge number = 1

Average grasp of concept - Gives a measure. Knowledge number = 2

Good grasp of concept - Gives a measure with an example. Knowledge number = 3

Excellent grasp of concept - Gives a few measures with examples. Knowledge number = 4

Figure 3.2: Perspectives from community focus groups on measures to be taken to minimise environmental impacts of fracking locally.

Figure 3.2 indicates that all of the respondents from various towns (except for the respondents from Colesberg) had large community and business groups that could not identify measures to be put in place for minimising fracking effects. These local community groups felt that they needed more information concerning fracking, its processes, pollution probabilities, and possible severity of impact. Without this information they could not indicate contingency plans to minimise effects fracking could have on their environments and local community. Some participants from these towns indicated that the information they had concerning fracking was gained from various media sources. This left them precariously positioned since they might not have a holistic understanding of fracking risk. They also indicated that this lack of information would prevent them from offering informed input, based on their institutional structures, concerning the management of risks associated with fracking. Colesberg and Victoria West participants indicated a measure to minimise environmental impacts of fracking as local businesses. Colesberg and Victoria West stated that they were actively against fracking in their area and that they would not allow fracking to take place on their various farms. Respondents from Britstown, Graaff Reinet and Victoria West indicated a measure along with an example of local business plans to minimise environmental impacts of fracking. This indicated measure was that all the farmers contribute to a trust in Graaff Reinet, which pays for a lawyer who specialises in fracking and laws directly or indirectly relevant to fracking. This lawyer establishes which laws need to be amended so that the community is protected

against future fracking or exploration, and according to them this inherently protects them from adverse environmental effects of fracking. This lawyer is knowledgeable concerning fracking risks and relevant laws pertaining to fracking, and therefore it stands to reason that this lawyer would be elected to serve on the DMAF. This lawyer would actively petition legal issues and address municipal regulations to ensure that fracking risks are reduced or mitigated. The lawyer would also be responsible for communicating DMAF information to the various stakeholders so that stakeholders are empowered and knowledgeable of possible risks discussed by the DMAF. Furthermore the farmers would communicate with fracking companies through this specific lawyer so that they are not blindsided by any additional information that might come to light concerning the possible environmental impact of fracking.

Respondents from Victoria West stated that they mobilised community members to constantly enquire concerning fracking and new fracking information to ensure that they can act or react as soon as deemed necessary to minimise environmental effects of fracking. These community members also expressed a willingness to work with fracking companies as long as the companies are up front concerning possible environmental risks during meetings and enquiry sessions. Ensuring that issues are further addressed would require that fracking companies would need to have representatives on the DMAF. The representatives of fracking companies would be required to address issues indicated by the DMAF so that all parties can work together to address fracking risks as comprehensively as possible.

Most participants felt that they would struggle to suggest any environmental or disaster risk management contingency plans relating to fracking on a DMAF since they do not have all the facts concerning possible environmental effects fracking could have. Participants highlighted that an institutional mechanism, such as the DMAF, is required to provide an environmental oversight role, thereby providing participants in the forum with insight into possible environmental effects of fracking.

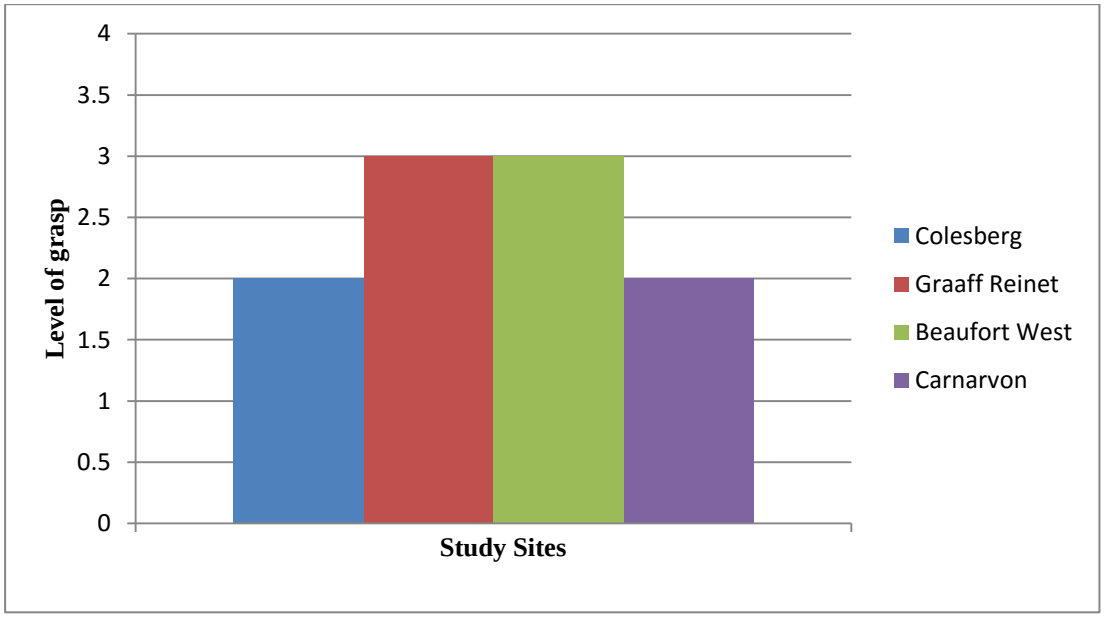
The various role-players and community members have different areas of input and advisory roles within the DMAF. The SA NDMF structure for DMAF would therefore need to be implemented in such a way that would allow different role-players to effectively communicate with one another to ensure effective exchange of relevant information. Since communities (including organised business) were encouraged to also aid in DRR and encouraged to avoid disasters, it is imperative to understand what they consider as their role when addressing fracking risks and minimising fracking risks. Their roles and input abilities differ, based on their set of skills and knowledge areas since respondents have such diverse responses to the research questions. The organised community groups' desire for more information concerning fracking is addressed if local government, organised community groups and fracking companies, formal DMAF for discussing fracking advantages and environmental effects. If the communities, for example, participate in these DMAF's they aid in DRR and therefore also inherently aid in protecting their own livelihoods, which mostly depend on groundwater systems in the area and extended environment outside of the town communities. The DMAF would therefore need structures to be set in place which allows

local community members to share their inputs within the DMAF. These structures enable effective distribution and use of unique roles and inputs local communities could contribute to the DMAF.

The following question specifically pertains to water management with relation to fracking and water availability in the Nama Karoo. This question is relevant to KPA 1, since decision making surrounding water would need to be addressed by the DMAF. Local government officials were queried as to what the process is to obtain water for fracking processes if and when fracking becomes operational in their areas. This question was asked to serve as an indicator assessing if a cursory risk assessment has been done relating to water resources which forms the basis of most livelihoods in the Nama Karoo.

3.2.3 Government opinion on securing water for fracking processes

This question can be found in the government questions annexture as question five. The table below presents the parameters of the question data analysis which is then presented in a bar graph format representing each of the participating local government officials.



No grasp of concept - Does not know where water would come from. Knowledge number = 1

Average grasp of concept - States that own water would not be enough but does not know where water would come from. Knowledge number = 2

Good grasp of concept - Knows local water would not be used. Has an idea that water would be transported from elsewhere. Knowledge number = 3

Excellent grasp of concept - Knows exactly where water would come from and local procedures. Knowledge number = 4

Figure 3.3: A local government perspective on securing water for fracking since the Nama Karoo is a water scarce area and fracking is a water intensive process.

Figure 3.3 indicates that government officials from Carnarvon and Colesberg realised that their water supply is not enough to be used for mining purposes since they do not have enough water for their own communities, even before fracking or other mining processes commenced. They also indicated that they did not know where the water would come from for fracking purposes. There is therefore an understanding of the physical vulnerabilities their communities face relating to finite water resources.

Beaufort West and Graaff Reinet government officials indicated that the water would be brought into town from elsewhere with trucks for the fracking process. During their assessment it did not appear that they have considered the finite nature of water supply in the region as a key risk factor to be considered with fracking. They indicated that it has been planned to bring water into the area by truck, which would lead to more accidents in their respective areas. This could also lead to more severe chemical spills which they would find difficult to deal with. The focus has been more on hazardous material spills. Dealing with chemical spills and environmental impacts require Disaster Management plans which needed to be implemented to protect the environment and communities. Comprehensive disaster management plans could only be drawn up if institutional arrangements for DRR, such as DMAF, established a detailed risk assessment along with a comprehensive fracking plan and fracking process schedule. Addressing the possible increase in the amount of accidents would therefore also qualify for identification of a new risk which is an example of the risks which would need to be discussed by the DMAF.

The cursory risk assessment indicates a fifty-fifty split between municipalities that consider fracking as an intervention that would negatively affect their strained water resources, and others that believe the risk can be mitigated by bringing in water for fracking from other areas. This difference in opinions point toward possible serious differences within the region on how to balance protecting water resources in the region versus possible economic opportunities associated with fracking. These contrary positions would have to be considered and discussed in either a DMAF or ICDM set up to manage fracking risk in the Nama Karoo. New risks such as increased risk for vehicle accidents and hazardous chemical spills should also be considered in such forums.

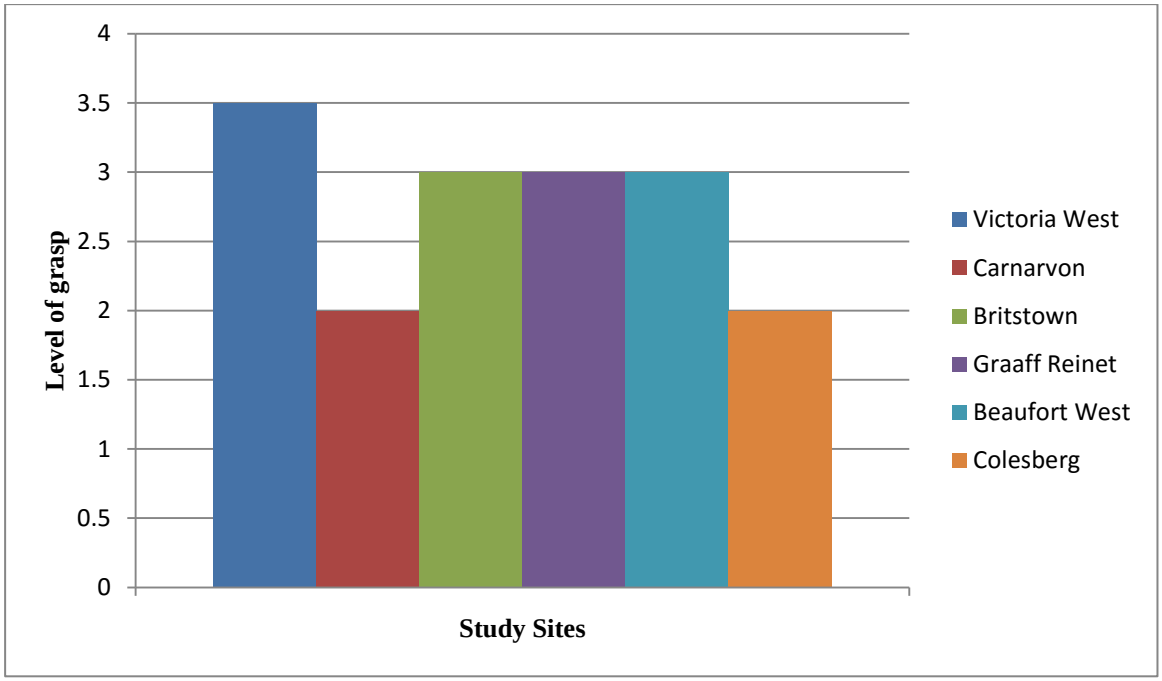
The formulation of disaster management frameworks and plans are not isolated from other government legislations and policies relevant to environmental management, water resources management and mining. All of these laws and legal frameworks have to be considered in the formulation of a disaster management framework; especially where disasters risk would overlap these policy areas.

This question also relates directly to KPA 1, since the DMAF need their local representatives to consider and understand the legislative frameworks in place which protect the environment and communities from pollution. These frameworks have to be considered through disaster management plans and frameworks. A community would be active participants in formulating a disaster management framework, and community respondents were asked if they knew which legislations and policies are protecting their environment and groundwater from pollution. The aim of the question was to determine community

participation and knowledge of legislation and policies currently protecting environment and groundwater, and also any legislation relevant to fracking.

3.2.4 Community grasp on general laws pertaining to environmental pollution and disaster risk laws

This question can be found in the community questions annexture as question eight. The table below presents the parameters of the question data analysis which is then presented in a bar graph format for each of the participating towns.



No grasp of concept - Knowledge number = 1

Average grasp of concept - Knows that there are laws but not specifically sure which ones they are. Knowledge number = 2

Good grasp of concept - Refers vaguely to some laws that are relevant. Knowledge number = 3

Excellent grasp of concept - Specifically refers to laws with examples for support. Knowledge number = 4

Figure 3.4: Focus group knowledge concerning legislations and policies in place to protect environment and groundwater.

Figure 3.4 had quite a few participants who indicated that they do not have any knowledge of laws which were in place to manage risks associated with fracking or current environmental matters. These participants were from Britstown, Carnarvon, Graaff Reinet and Victoria West. The participants from these towns indicated that they make use of lawyers if a situation presents where they would require information on relevant laws regarding fracking. It was mostly indicated that as communities, they did not necessarily need specific knowledge, and they can rely on their committees and lawyer friends to

inform them in cases where they need legal aid. Communities also indicated that they relied more on their traditional knowledge passed on from generation to generation to effectively manage their resources and perceived risks, rather than counting on legislation.

Some participants from Britstown and Colesberg indicated that there are laws in place protecting environment and groundwater and also indicated that they were not sure what the specific laws were. It has been mentioned that they believed the Environmental Affairs and Water Affairs Departments would be primarily responsible for protecting water resources within the Nama Karoo. It was indicated that, if need be, they would launch a government complaint if something were to happen.

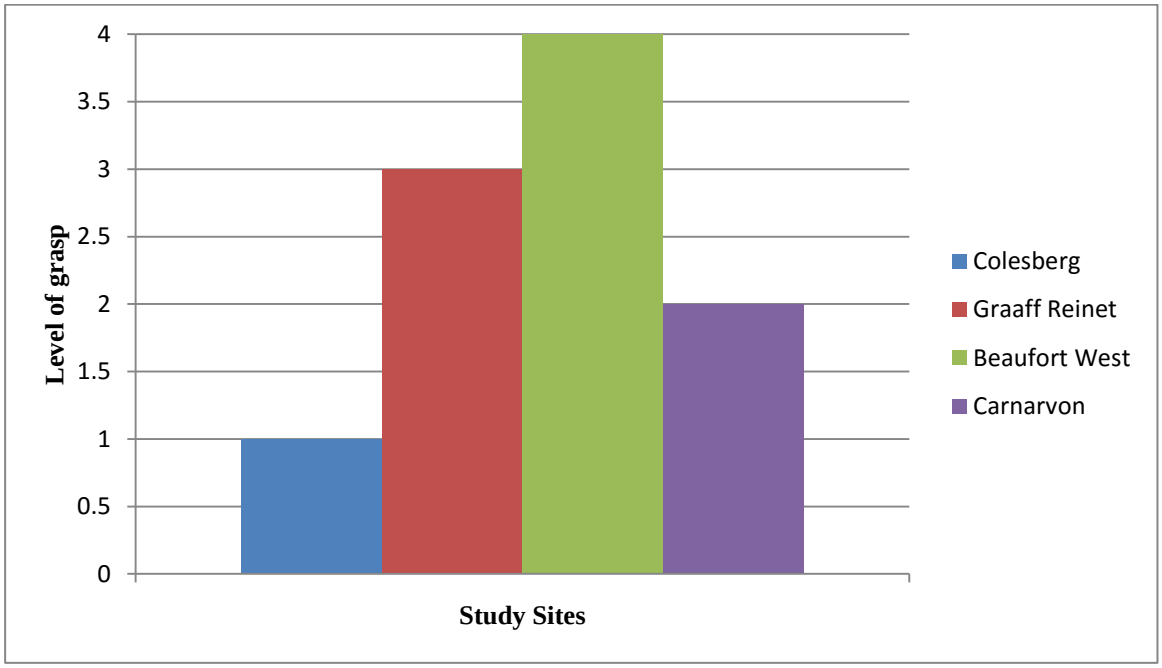
Respondents from Beaufort West, Graaff Reinet and Victoria West briefly alluded to relevant environment and groundwater laws which have bearing on management of fracking risk in the Nama Karoo. They also emphasised the important role of the Department of Water Affairs and Department of Environmental Management in managing fracking risk. They felt that these national government departments would play an important advocacy and law enforcement role, since they were not be able to do much since their communities were too small to be taken seriously when they complain about the conduct of fracking companies.

Some participants in Graaff Reinet highlighted specific water, environmental and constitutional laws with examples to support these laws. These specific laws were identified by a lawyer who participated in one of the focus groups. This lawyer was seen as the person who should know relevant laws and legislations since he visited America to gain insight on what was going on in the areas already subject to fracking. This lawyer stated that his team of lawyers were working on having legislation and laws amended to include protection against fracking for communities which could be affected by the fracking process. This lawyer also pointed out that they had to start at the national government legislation level so that amendments in laws can be passed down to provincial and local governments.

The answers that have been received necessitated the need to determine what local government officials comprehend as relevant legislations and policies which protect environment and groundwater from pollution. The aim of this question was to determine if the problem of ‘not knowing’ what other legislations and frameworks were, is also applicable to formulation of a disaster management framework on an institutional level (officials not knowing), or whether it was a question of lacking awareness between the officials and community.

3.2.5 Government grasp on legislative frameworks pertaining to pollution protection

This question can be found in the government questions annexture as question six. The table below presents the parameters of the question data analysis which is presented in a bar graph format for each of the participating local government officials.



No grasp of concept - No knowledge of any legislative frameworks. Knowledge number = 1

Average grasp of concept - Knows which legislative frameworks there are but does not know how it will apply. Knowledge number = 2

Good grasp of concept - Knows what a legislative framework is and knows there are none in place but feels that there should be. Knowledge number = 3

Excellent grasp of concept - Knows what a legislative framework is and knows of a few which are in place (relevant or irrelevant to environmental pollution) with an example. Knowledge number = 4

Figure 3.5: Local government perspective concerning the legislative framework which would protect the environment and communities from fracking pollution.

Figure 3.5 indicates that local government respondents from Colesberg said that they cannot answer this question due to their lack of information concerning laws and government frameworks that could protect them concerning fracking risk. Local government respondents from Carnarvon indicated that they usually formulate ad-hoc frameworks to address risks as they occur. For example, in the case of droughts, a framework would be formulated that would outline the procedures pertaining to what the response should be in case a drought occurs in their area. The frameworks were used as a guideline and some processes within the framework were left to interpretation or not implemented at all. The issues of not currently having a concrete policy in place to deal with pollution at the scale expected from fracking were also raised. As there were no large industries in the area, there was never a need to develop any form of local municipal legislative frameworks that incorporated legal considerations relating to

pollution, mining or large industries. Therefore there is a significant gap in terms of having a legislative framework in place to address the holistic nature of fracking risk.

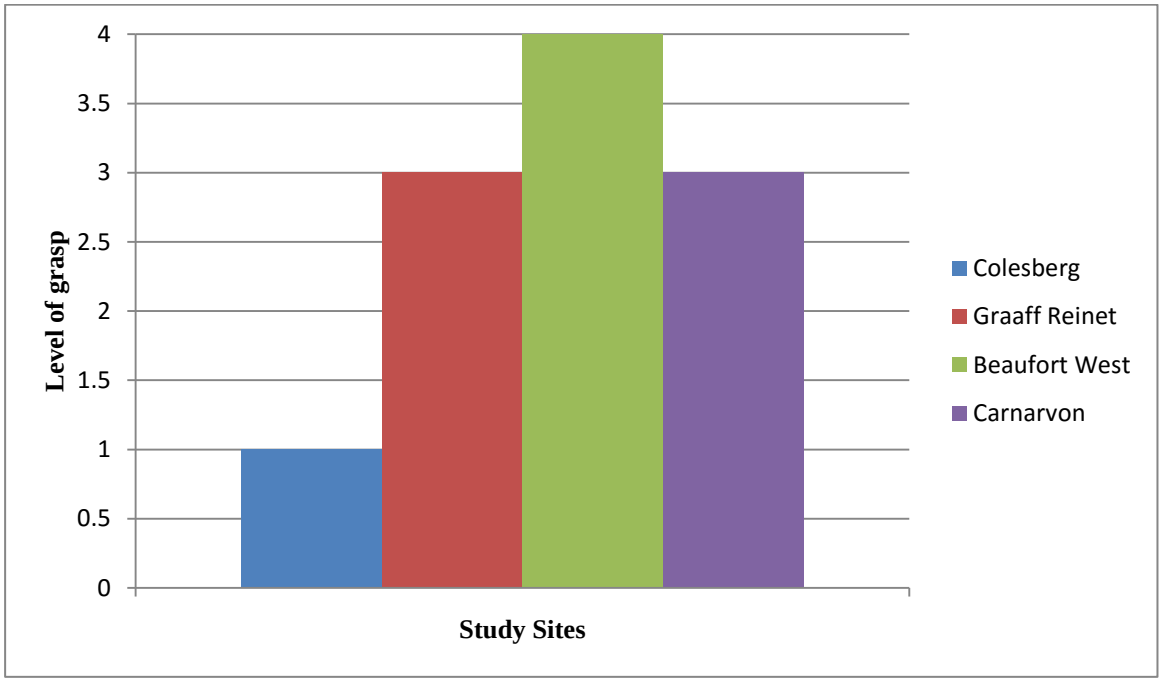
Local government respondents from Graaff Reinet also stated that they do not have any legislative frameworks. The only plan they had in place was to advise the farming community to test their water and groundwater, and to identify the possible fracking risks for integration in their disaster management plan. It was noted by officials that information on fracking risk still need to be integrated into official disaster management plan. An official from Graaff Reinet felt that only the disaster management plan would be able to protect them, since fracking companies have significant political and economic influence. Local government respondents from Beaufort West also noted that their town did not have any formal framework in place for fracking risk mitigation. A government official mentioned that national regulations surrounding fracking were still unclear, and preferred regulation would need clarification before they would be able to implement anything on local government level. Government officials also indicated that they need direction and support from national government level, to enforce governing framework at a local level, and fracking companies would be less likely to ignore such frameworks. The inclination to ignore local government frameworks is ascribed to fracking companies being rich and powerful with vast political influence.

A crucial aspect often ignored when addressing KPA 1, is the need to create an adequate framework to manage disaster risk. Naturally, with fracking being a comprehensive risk that also incorporates issues concerning water, mining and pollution, it would be necessary to integrate or take note of existing frameworks in any proposed disaster risk management framework. Considering the analysis above, it is clear that most towns in the Nama Karoo do not have extensive frameworks to manage the risks (water pollution, environmental pollution or disaster risk) associated with fracking. Respondents (both government and communities) indicated that input from national government is notably needed to establish guidance, understanding and substance to the risk management frameworks that require development by the SA NDMF.

The following question focuses on how government plans on monitoring and maintaining compliance regarding disaster management frameworks established in accordance with KPA 1. Monitoring compliance with developed frameworks is viewed as an important aspect that needs to be integrated into any framework since South African government institutions tend to have very well developed legislation, associated with poor implementation. Therefore, issues aiding or diminishing compliance need to be highlighted.

3.2.6 Government opinion on maintaining compliance with legislative frameworks

This question can be found in the government questions annexture as question eight. The table below presents the parameters of the question data analysis which is then presented in a bar graph format for each of the participating local government officials.



No grasp of concept - Not aware of any measures to maintain any compliance. Knowledge number = 1

Average grasp of concept - Knows that there are laws for compliance but not specifically sure which ones they are or how they work. Knowledge number = 2

Good grasp of concept - Refers vaguely to some compliance insurance efforts that are relevant and realises personnel are not enough. Knowledge number = 3

Excellent grasp of concept - Specifically refers to compliance frameworks with examples for support but also realises that personnel are not enough. Knowledge number = 4

Figure 3.6: Local government perspective on maintaining legislative compliance to protect environment and groundwater.

Figure 3.6 indicates that local government respondents from Colesberg gave the indication that they do not have any legislative frameworks in place to manage fracking risk. Furthermore, respondents indicated that their lack of fracking knowledge would restrict their ability to integrate appropriate compliance monitoring practices into future frameworks. Local government respondents from Carnarvon and Graaff Reinet indicated that there are adequate laws available. An official from Graaff Reinet indicated that he already has compiled a draft disaster management plan which also addresses fracking (as per community demand). The same official highlighted the central role of the community (civil-society) in monitoring compliance with their own and national government frameworks:

"*In Graaff Reinet the community checks up on the government to make sure disaster risk plans containing fracking are in place and the community wants updates from local government*".

Local government respondents from Carnarvon indicated that their district is very large, which makes it difficult to monitor legislative compliance. There are significant human resources shortages (very few officials for a large area). The local municipality of Carnarvon is very reliant on provincial and national government for regulations and additional personnel aid, to maintain compliance. Furthermore respondents highlighted that they were not aware of precise laws in place pertaining to fracking. This would complicate compliance monitoring since the law needs to form the foundation and directive of what should be complied with.

Beaufort West's local government official believes that they would need to amend the laws to ensure compliance, since the only regulations in place comes directly from the fracking companies and not specifically from government. This government official also stated that South Africa has a lot of adequate laws indirectly pertaining to fracking, although policing of these laws were considered to be lacking due to human resource shortages and lack of government official capacity (skills, understanding of laws and willingness to comply). The government official further stated that:

"*There are not enough people, for proper policing of current laws. Therefore even if the laws are in place it will be difficult to ensure compliance*".

During the research interviews it was found that there are very few institutional structures in place for disaster management that could actually ensure compliance with the prescripts of the DMA and SA NDMF. As such a situation exists where, for example, integrated development plans are confused with disaster management plans. In some instances government officials also misunderstood 'disaster management plans' for plans that only focus on water management and environmental pollution management. In these instances a local disaster management framework should emphasise roles and responsibilities of all stakeholders relevant to monitoring and evaluation of activities conducted by disaster management. The local government respondents from the various towns also indicated that human resource shortages need to be addressed. These human resource shortages hamper disaster risk structure management which could complicate the sustainable implementation of DRM policies and programs at municipalities.

Relating to KPA 1, local government and communities from all municipalities definitely acknowledged the need for DRM structures. It was also suggested that various stakeholders should take part in the DMAF to give their inputs. DRR can only be done if a DMAF is established which includes members from local governments, organised community groups and fracking companies. Having access to such a diverse set of inputs and opinions provides for a more comprehensive disaster management plan concerning fracking. The involvement of such a diverse set of stakeholders could also be used to aid in

compliance and monitoring strategies in the absence of necessary human resources. The involvement of multiple groups also has benefits for the process of disaster risk assessment. Section 3.3 discusses the disaster risk assessment (KPA 2) and questions relevant to it.

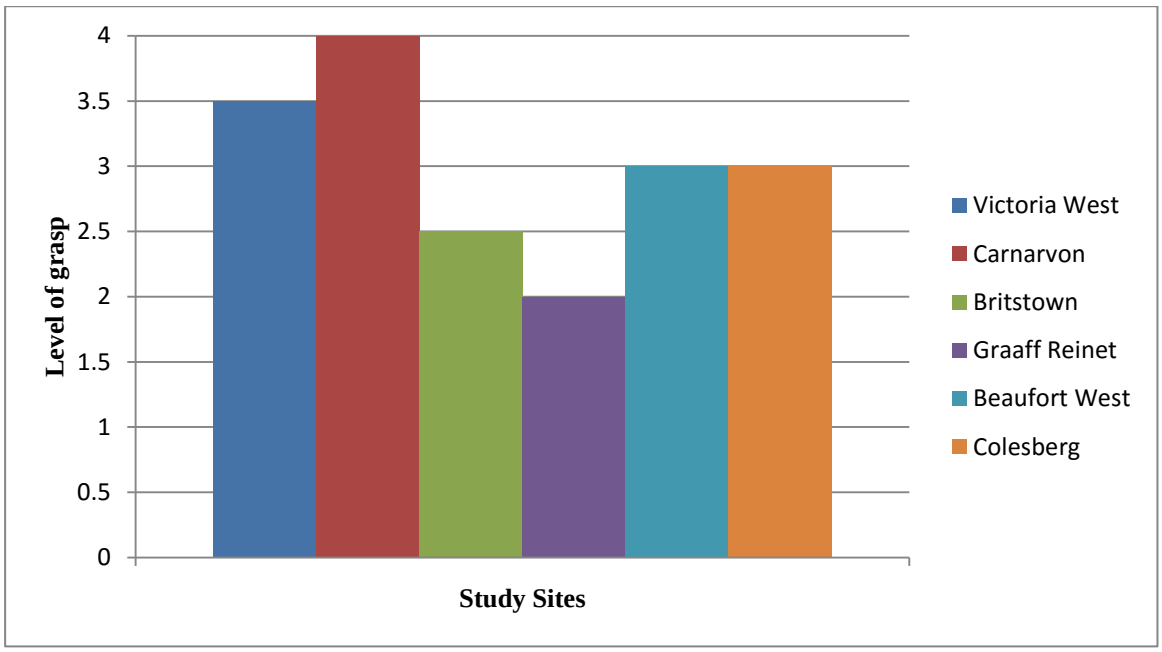
3.3 KPA 2: Disaster Risk Assessment

This performance area addresses the need for disaster risk assessments and monitoring which guides risk reduction. Disaster risk, as per the framework, places emphasis on several key steps including, determining hazards and vulnerability profiles, as well as identifying societal capacity and risk prioritisation. Fracking can be considered a prominent risk for the Nama Karoo and it is therefore crucial to identify the extent of hazard, vulnerability and coping capacity of communities that are likely to be affected. Importance is especially to determine issues concerning societal vulnerability, as communities are likely to experience additional vulnerabilities, since their main source of income depend on farming and farming practices. These farming practices depend on a limited water supply, which is highly likely to be polluted by fracking. Based on these concerns and problems which were highlighted, the following questions were directed at communities and government officials.

The first question relevant to KPA 2 pertains to organised community group perspectives on the positive and negative impacts of fracking. This question was directed at the communities concerned in this research study as well as relevant local government representatives. The aim of this question was to determine if local government and the community has done a cursory disaster risk assessment pertaining to fracking, and possible effects of fracking on environment, groundwater and socio-economic conditions (added vulnerability or capacity).

3.3.1 Community opinion on fracking impacts on communities

This question can be found in the community questions annexture as question three. The table below presents the parameters of the question data analysis which is then presented in a bar graph format for each of the participating towns.



No grasp of concept - Does not give any positive or negative impacts. Knowledge number = 1

Average grasp of concept - Gives one positive or one negative with an example. Knowledge number = 2

Good grasp of concept - Gives a few positives or negatives with examples. Knowledge number = 3

Excellent grasp of concept - Gives positives and negatives with examples. Knowledge number = 4

Figure 3.7: Focus group perspectives on positive and negative impacts of fracking on communities within the fracking area.

Figure 3.7 indicates that a few participants in Britstown and Graaff Reinet did not indicate any positive or negative impacts of fracking on their community. These community members indicated that one could not simply list various positives and negatives, since there are too many fracking related variables. Community participants also indicated that negative and positive consequences would emerge from fracking based on how government manages fracking related situations. In Britstown, Carnarvon and Graaff Reinet participants had at least one positive or negative impact to contribute to the impact fracking could have on communities. The Graaff Reinet community members indicated that fracking could cause the same type of migration that was caused by the gold rush. This analogy is associated with a large influx of people into the Graaff Reinet area, which could, firstly, put strain on basic service delivery distribution to the rest of the community, and secondly bring social friction into the community. This analogy is further based on the assumption that the criminal element might increase as a result of unemployment. This could increase the social vulnerabilities in the area.

Respondents from Britstown were concerned with what would happen to the town and people who work at fracking towers, after fracking has been completed, and fracking towers move their operations. This concern therefore relates to economic vulnerability following closure of fracking operations. Carnarvon respondents stated that they were concerned that fracking companies will not adhere to their obligations and commitments towards the town's community. These obligations and commitments are contextualised

as any and all promises relating to employment or contribution of finances to social development projects in the town by the fracking company. The participants also indicated their concerns regarding the rehabilitation of environment after fracking towers have been closed down. The communities were concerned that if fracking companies neglected adhering to these obligations and commitments, it could have adverse effects on the town and its extended community.

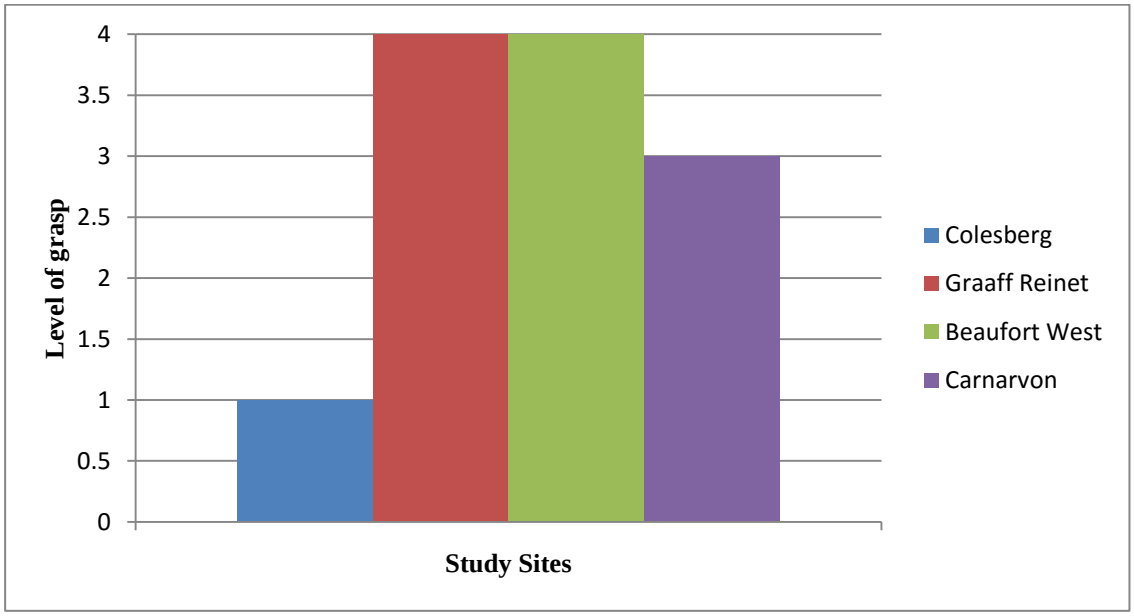
Respondents from Victoria West also highlighted some positive and negative impacts of fracking in their cursory risk assessment. They elaborated quite extensively on the fact that the community could gain cash influx since there will be an increase in economic activities in and around the town (more employment, more businesses opening up). The assumption was made that if more people were employed, the social grant dependence in town could potentially decrease. This would enhance the economic capacity of vulnerable community members and lessen overall disaster risk. Some participants from Victoria West indicated that tourism will decline due to industrialisation of the area. Groundwater could also be contaminated which would influence livelihoods, and there could be an increase in crime if the workers lose their employment opportunities at fracking towers.

Assessment of the organised community members mostly only identified short term economic advantages associated with fracking, i.e. increase in economic capacity and less social vulnerabilities. Most of the community responses, however, mainly focused on long term vulnerabilities that communities would experience when fracking stops. The long term vulnerabilities were related to economic, social and environmental vulnerabilities which would be caused by fracking. The communities indicated that the possibility of long term livelihood harm or loss could be a notable reality if fracking risks were not properly managed.

The discussion above also highlighted issues of perspectives with regard to fracking risks. Poorer community members might for instance welcome fracking since it presents hope of improved livelihoods and lessen economic vulnerability. On the other hand, farmers oppose fracking since it could, most likely, cause loss of their livelihood if water resources are polluted. For farmers fracking poses both an economic and physical vulnerability risk. It is therefore clear that if fracking risks are to be addressed, a diverse and holistic impression should be fostered of positive (capacities) and negative (vulnerability) impacts of fracking. To this end it was also crucial to ascertain positive and negative impacts noted by local government officials from each town. This question also serves as a proxy indicator for indicating whether or not a cursory risk assessment had been done by local government officials.

3.3.2 Government opinion on fracking impacts on communities

This question can be found in the government questions annexture as question three. The table below presents the parameters of the question data analysis which is then presented in a bar graph format for each of the participating local government officials.



No grasp of concept - Does not give any positive or negative impacts. Knowledge number = 1
Average grasp of concept - Gives one positive or one negative with an example. Knowledge number = 2
Good grasp of concept - Gives a few positives or negatives with examples. Knowledge number = 3
Excellent grasp of concept - Gives positives and negatives with examples. Knowledge number = 4

Figure 3.8: Local government perspectives on the positive and negative impacts of fracking on communities within the fracking areas.

Figure 3.8 respondents from Colesberg once again declined to answer and indicated that before answering this type of question they would need to be informed by the concerned fracking companies concerning: what is being planned and how the processes would work. These respondents therefore do not currently have an understanding of the positive or negative impacts (hazards or vulnerabilities) associated with fracking. Local government officials from Carnarvon indicated that they believe employment opportunities could be created for their community members.

"*Having a poor community, these employment opportunities would make a large difference and would be welcomed*".

Their emphasis was therefore focused on the possible reduction of economic vulnerabilities in their community. A respondent indicated that he was not certain of the negative aspects of fracking since he did not know much about fracking and its processes. These government officials were unaware of possible long term social, physical and environmental vulnerabilities associated with fracking.

Graaff Reinet's government official also indicated that employment opportunities could be created by expansion of the town as well as a monetary injection into the town. Other improvements which were indicated were associated with possible further educational sponsorship as well as monetary sponsorships (by fracking companies) for improvement of the town. A government official indicated that community structures (such as farmers associations) in town were usually opposed to dramatic change. Since fracking could inevitably lead to changes in the area these community structures were strongly opposed to fracking. Although the respondent from Graaff Reinet mostly highlighted positive impacts of fracking they were concerned about introduction of social vulnerabilities:

"*Crime is also projected to increase since fracking would draw questionable outsiders to the area*".

It was also indicated that water and air pollution is a concern. The issue concerning water pollution (physical vulnerability) was especially emphasised since officials felt they have to upgrade water purification systems to address the possible adverse impacts of fracking. However, officials alluded to the fact that perceived economic benefits of fracking mitigated some of their concern:

"*As long as the young community members are off of the streets and doing something positive it would be beneficial*".

The Beaufort West government official indicated that he thought the whole of South Africa's employment opportunities would increase and not necessarily employment opportunities in Beaufort West. The prospect was that 300 000 employment opportunities could be created throughout South Africa. The reasoning behind this opinion was that the community members from Beaufort West would not have the required qualifications or knowledge, required to work at a fracking tower. Only a highly skilled and qualified workforce would be appointed to work at fracking towers and these technicians, engineers and specialists would be brought in from all over South Africa and the rest of the world since they would not necessarily be found in Beaufort West or even South Africa. Local residences would prospectively only fulfil supporting roles, such as cleaners, etc.

The positives and negatives highlighted by government officials, mostly focused on possible economic benefit and reduction of economic vulnerability in their area. Local government largely focused on short term benefits instead of long term impacts. Compared to local government responses, the organised community group responses are clearly different. The organised community group respondents focused on long term effects and vulnerabilities associated with fracking and government focused on short term benefits. For the purpose of more in depth disaster risk assessment it is important to take note of both the long-term and short-term risk perspectives highlighted by the community and local government officials. Considering both of these perspectives in a risk assessment could enable municipalities to formulate disaster risk management and risk reduction strategies that address the concerns indicated by both interest

groups. Section 3.4 further conceptualises disaster risk and the measures required for DRR to be successful in the Nama Karoo.

3.4 KPA 3: Disaster risk reduction (DRR)

This KPA addresses the introduction of DRM planning and implementation of available disaster management plans. This performance area is developmentally-oriented and uses various approaches, plans, contingency plans, programmes, and projects to reduce disaster risks. The primary issues that were highlighted are formulating disaster management plans and different levels of planning that are build on each other to reduce risk. It also follows requirements for alignment between disaster management frameworks and development planning (economic and social development programs) within all spheres of government. It further focuses on planning for and integration of core risk reduction principles concerning prevention and mitigation of ongoing programmes and initiatives that are set in place (SA NDMF, 2005). The relevance of this KPA to fracking is that, since fracking is still in the development phase, proper planning and risk reduction measures can still be identified and drawn up for implementation purposes. Ensuring that comprehensive and integrative risk reduction measures are taken by local government, a contextualisation is required concerning what the critical outcomes are, which local government needs to address DRM for fracking at a local level.

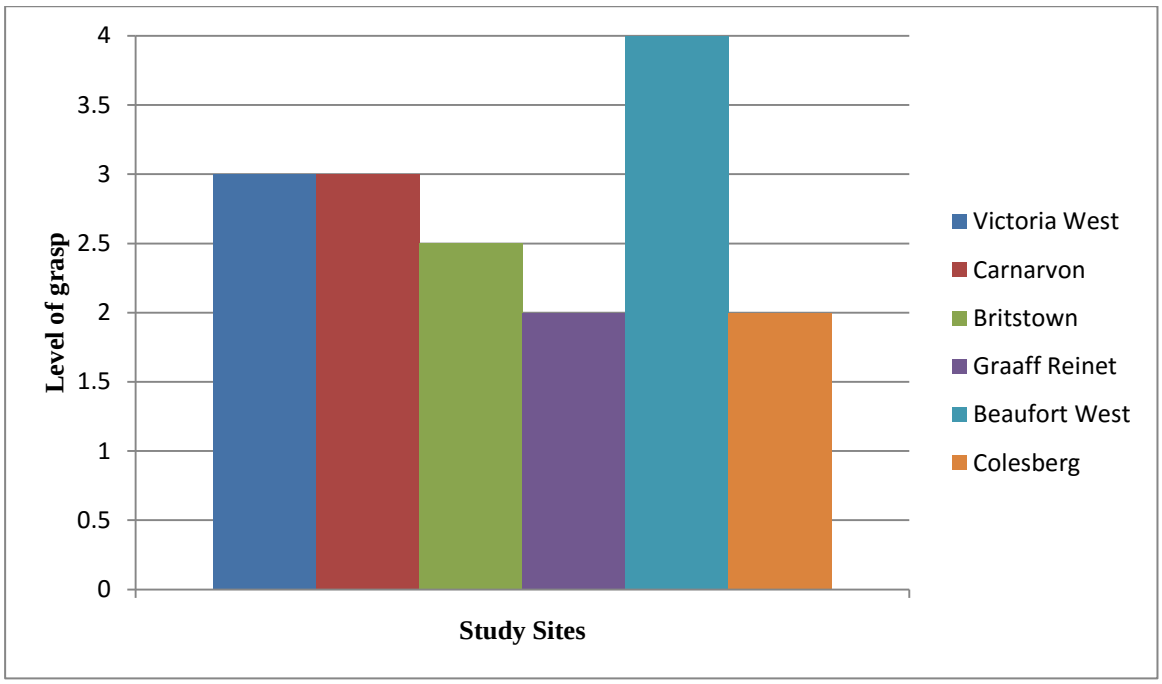
The level based critical outcomes are presented in Table 3.1 of Section 3.2. Level one requires that government spheres, without coherent disaster risk management plans, need to establish foundational institutional arrangements for disaster risk management. This entails putting in place contingency plans for responding to known priority threats which were identified during the initial stages of the disaster risk assessment. It identifies key governmental and other stakeholders while developing the capability to generate a comprehensive level two DRM plan (SA NDMF, 2005). Level two critical outcomes pertain to government spheres with established foundational institutional arrangements. Level two thus focuses on building the essential supportive capabilities which are needed to apply comprehensive DRM activities. This level includes establishing processes which enable comprehensive disaster risk assessment, identifying and establishing formal consulting mechanisms for development of disaster risk reduction projects, and introducing supportive information management and communication systems coupled with emergency communication capabilities (SA NDMF, 2005). The critical outcomes of the level three DRM plan pertains to government spheres with both foundational institutional arrangements for DRM, and essential supportive capabilities. The plan is required to specify institutional arrangements for co-ordinating and aligning the DRM plan with other governmental initiatives and plans of institutional role players. Evidence should also be provided of informed disaster risk assessment and ongoing disaster risk monitoring capabilities, along with the relevant developmental measures reducing vulnerability of disaster-prone areas, communities and households (SA NDMF, 2005).

Within Section 3.2 government official responses concerning their respective levels of disaster management plans were contextualised. There is a clear difference in the disaster management levels being implemented and applied within various local government participants' towns. An irregularity has also been identified in the form of IDPs being mistaken by local government for comprehensive and applicable disaster management plans. An IDP is only an aid for local government to establish foundational institutional arrangements; it does not serve the purpose of a disaster management plan at any level. The problem associated with this irregularity is that the IDP context does not require risk assessments to be done, and neither does it require a DMAF structure to be followed to be able to gain insight into comprehensive community and environmental risk. Therefore the IDP is not supported by the necessary role players and structures to replace a comprehensive disaster management plan; an IDP only supports critical outcomes and integration required for level one to three disaster management plans. The confusion associated with IDP function and DRM function hampers fracking risk identification through the Nama Karoo region. Furthermore the impediment of fracking risk identification could limit the strategies which address fracking risks, such as contingency planning. An IDP also does not require contingency planning which is a key component to ensure that KPA 3 is implemented, as required by the SA NDMF. The uniform development of DRM planning between local governments within the Nama Karoo could minimise impeding effects of non uniform DRM development has caused, and enable improved fracking risk identification and strategic planning development.

Contingency planning is a key component in ensuring that the objectives of KPA 3 are achieved. Existing contingency plans cannot be seen in isolation from an inclusive disaster management plan since they would have to be legally integrated into a final disaster management plan (as per the requirements of KPA 3). As such it was imperative to understand current community opinions related to contingency planning surrounding water and environmental pollution. As a point of departure the community was asked if they were aware of contingency plans addressing pollution of water or environment in their area. This establishes the current programmes and initiatives which could be in place to guide response interventions if something were to go wrong. The aim of this question is to serve as a proxy indicator for the level of contingency planning that is currently implemented in the Nama Karoo area, for fracking related disaster risks.

3.4.1 Community understanding of contingency plans in place for water pollution

This question can be found in the community questions annexture as question six. The table below presents the parameters of the question data analysis which is then presented in a bar graph format for each of the participating towns.



No grasp of concept - No knowledge of any contingency plans for pollution. Knowledge number = 1

Average grasp of concept - Knows what a contingency plan is but does not know of any in place, only local knowledge passed along. Knowledge number = 2

Good grasp of concept - Knows what a contingency plan is and knows there are none in place but feels that there should be. Knowledge number = 3

Excellent grasp of concept - Knows what a contingency plan is and knows of a few which are in place (relevant or irrelevant to water pollution) with an example. Knowledge number = 4

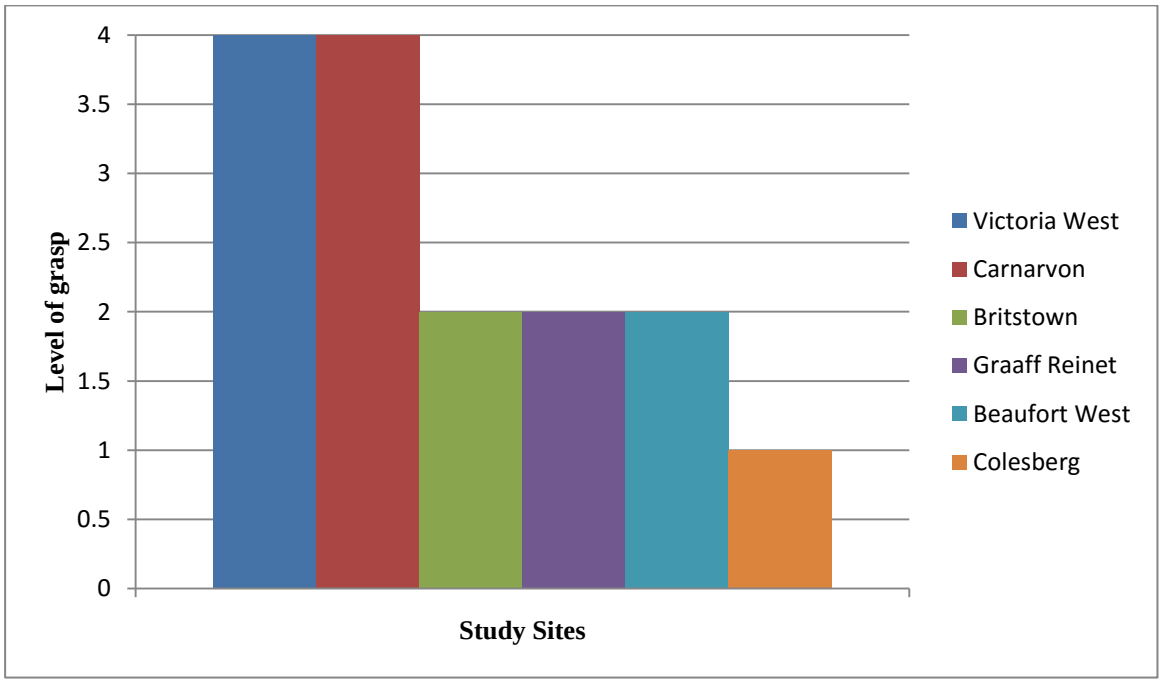
Figure 3.9: Focus group perspectives on how fracking is linked to water pollution and possible contingency plans to minimise the pollution of natural streams, dams and groundwater since the Nama Karoo is a water scarce area.

Figure 3.9 indicates that respondents from Graaff Reinet were the only participant group who had no idea what contingency planning involved on a theoretical or practical level for water pollution in their community. Respondents from Britstown, Colesberg and Graaff Reinet indicated that they knew what contingency plans were, in theory, but were unaware of any contingency plans in place in their respective towns to practically address the water pollution risk related to fracking. Beaufort West participants were the only ones who indicated that their town had some contingency plans for protecting water resources (although these were mostly geared towards other risks such as drought). Respondents alluded that their contingency plans for managing water resources depends mostly on reverse osmosis. It is believed that if water resources become polluted, reverse osmosis could be utilised to address the problem. Respondents also indicated that other water resources they depended on are the groundwater system of Beaufort West. This groundwater system has, in the past, aided the town in coping with drought situations, since the Gamka dam is not the main water source to carry the town throughout the year.

The overall response to this question was that respondents understood what contingency plans are and why they would be necessary to address risk. There are, currently, very few or no practical contingency plans in place to address fracking risks, let alone water management issues. In the absence of contingency plans, it can be argued that overall community risk has increased, and if there is no plan in place to effectively address any water pollution caused by fracking, most people in the region, who depend on water for their livelihood, could potentially suffer severe consequences. In the perceived absence of government based contingency plans, community respondents were asked if they had any contingency plans in place or in mind to address fracking risks. The aim of this question was to establish if communities could contribute significant contingency strategies into overall disaster management planning via a mechanism, such as the DMAF.

3.4.2 Community contingency plans for minimising environmental impacts caused by fracking

This question can be found in the community questions annexture as question four. The table below presents the parameters of the question data analysis which is then presented in a bar graph format for each of the participating towns.



No grasp of concept - No answer given. Knowledge number = 1

Average grasp of concept - No contingency plans. Knowledge number = 2

Good grasp of concept - Gives a contingency plan although it is not in place. Knowledge number = 3

Excellent grasp of concept - Gives a contingency plan which is relevant. Knowledge number = 4

Figure 3.10: Focus group perspectives on contingency plans in place/ mind in case fracking has a negative impact on environment.

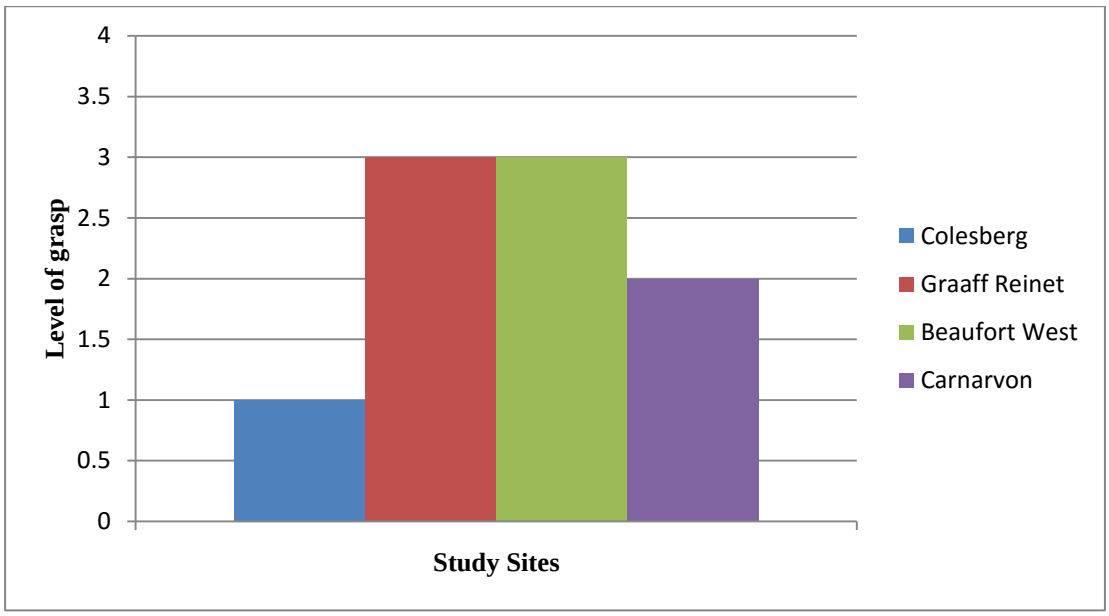
Figure 3.10 indicates that some community respondents from Beaufort West, Britstown, Carnarvon and Graaff Reinet had no contingency plans since they felt the possible negative impact of fracking would be so extensive that nothing they undertook would address the problem. They also indicated that a lack of information curtailed any efforts to formulate their own contingency plans. Some business owners in the focus groups felt that they could not financially implement a viable contingency plan due to the nature of their businesses. All of the participants are reliant on clean water to be able to keep their businesses (i.e. livelihood) running. They elaborated that contingency plans, such as trucking in clean water from other towns and provinces (as proposed by some municipal officials), would be too expensive to be considered a long term solution and would likely lead to closure of many businesses.

Respondents from Britstown and Graaff Reinet presented a contingency plan which they are considering. Their idea was to have the fracking companies supply their own water for fracking purposes and they put up a purification plant for the generated flowback, since they were directly responsible for contaminating the water being used for fracking process. This purification plant would then require a panel of trustees, consisting of various experts, to ensure that the water being purified meets required standards and that the plant is properly maintained. Respondents from Victoria West presented examples of contingency plans they have discussed and plan on implementing at certain stages in the fracking process of exploration, all the way through to mining and production of gas in the area. The specifics of this plan were not shared due to lack of specific knowledge and also confidentiality between the participants, their lawyer and other unspecified parties.

With relation to the two community questions presented above directly linked to KPA 3, it is clear that organised community groups indicated that contingency plans were lacking at government level. They also indicated that they would need more information concerning fracking to enable drawing up and implementing contingency plans for their businesses when fracking commences. The local government was asked similar questions relating to contingency planning and DRM. Based on KPA 3, local governments were required to contextualise the measures they would take to minimise environmental impacts of fracking and contingency plans they had in place or mind if fracking does cause adverse effects. The result of this question is relayed in Figure 3.11.

3.4.3 Government measures for minimising environmental impacts of fracking

This question can be found in the government questions annexture as question four. The table below presents the parameters of the question data analysis which is then presented in a bar graph format for each of the participating local government officials.



No grasp of concept - Gives no measures. Knowledge number = 1

Average grasp of concept - Gives a measure. Knowledge number = 2

Good grasp of concept - Gives a measure with an example. Knowledge number = 3

Excellent grasp of concept - Gives a few measures with examples. Knowledge number = 4

Figure 3.11: Local government perspectives on minimising the environmental impacts of fracking.

Figure 3.11 indicates that local government respondents from Colesberg did not have any knowledge of any measures which government could take to minimise environmental impacts of fracking. Therefore clear contingency plans were lacking. The local government official from Carnarvon indicated that the national and provincial governments has, thus far, neglected to inform them concerning official fracking regulations. This has hindered formulation of any contingency plans, especially plans aligned with national and provincial fracking standards. Local government respondents from Beaufort West and Graaff Reinet indicated that the only problem they could address was to design and implement a satisfactory disaster management plan, addressing fracking risks and related contingency plans. They also had to ensure that once the plan is formulated, it is required to be implemented and maintained, if fracking risk is to be addressed.

Clearly some towns, such as Beaufort West and Graaff Reinet have established some DRR and contingency strategies. The extent of these DRR methods is still limited to these two towns. The other local government representatives who took part in the study indicated the lack of concrete contingency disaster plans or contingency planning. In situations where local government still has to formulate disaster management plans it would be imperative to properly brief officials concerning the extent of fracking risk. The indicated lack of information was identified by respondents as an impediment to their disaster and contingency planning activities. The respondents also indicated that a proper briefing by other levels of government (national and provincial disaster management) and fracking companies would lead to a more comprehensive disaster management plan, and DRR methods being drawn up by the local

disaster management centres in the Nama Karoo affected by fracking. Such a comprehensive disaster management plan is necessary to present extensive guidance on all possible DRR strategies related to fracking. Once DRR strategies were formulated it would be crucial to distribute the information contextualising fracking risks, and methods to present them to multiple stakeholders (towns' councils, all spheres of government, companies implementing fracking processes and communities) in the Nama Karoo. Enabler 1 of the SA NDMF acts as guidance for information management and communication aspects in DRM. Section 3.5 elaborates on specific issues in this regard.

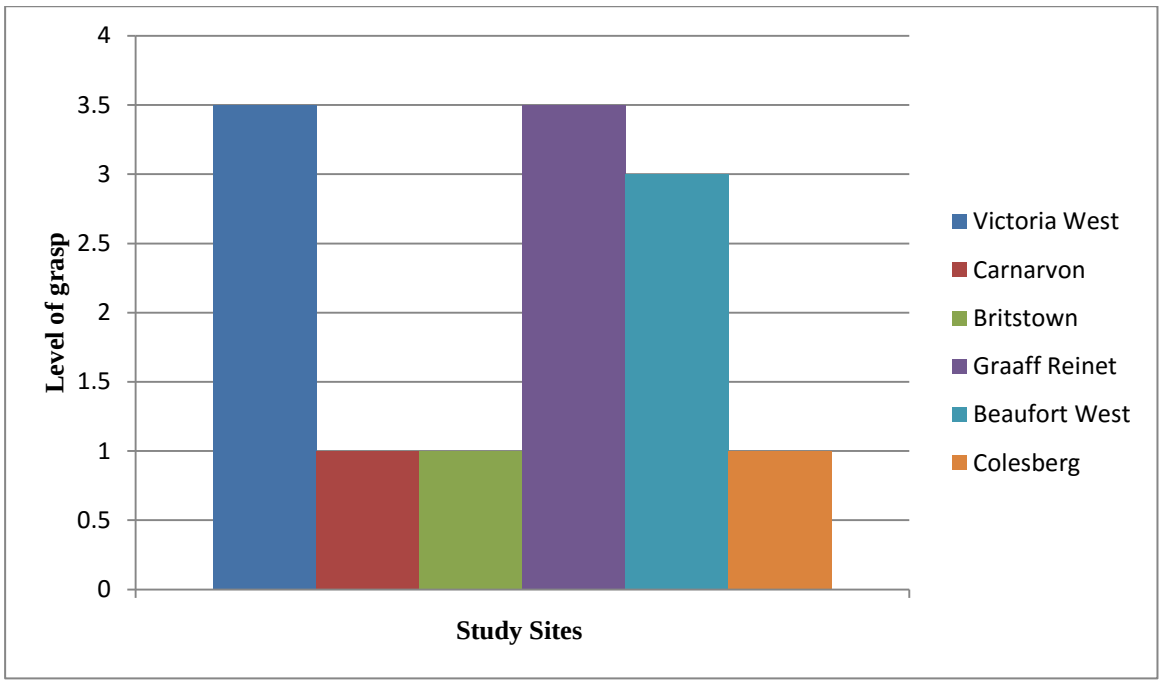
3.5 Enabler 1: Information management and communication

This enabler guides the development of comprehensive information management and communication systems which should establish integrated communication links with all relevant DRM role players, such as communities and government (SA NDMF, 2005). The questions related to Enabler 1 addresses communication between community members, government officials and fracking companies. If communication is lacking, role players are often not aware of the extent of risk(s) they face. Investigating implementation of this enabler in the Nama Karoo fracking context is very important, since initial indications (as per the reviews of other KPA above) show that many role players (government officials and community members) are not fully aware of the myriad of risks and vulnerabilities associated with fracking.

The first question pertaining to Enabler 1 was directed at both community participants and relevant government representatives. This question is aimed at determining whether the participants have received face-to-face, written or technological communication concerning fracking or other communication related to fracking. The first question presented represents the organised community group responses followed by the local government responses.

3.5.1 Community opinion concerning fracking related communication

This question can be found in the community questions annexture as question seven. The table below presents the parameters of the question data analysis which is then presented in a bar graph format for each of the participating towns.



No grasp of concept - No knowledge of any communication. - Only newspaper knowledge and knowledge from TV. Knowledge number = 1

Average grasps of concept - Knowledge of communication appointments but did not attend. Knowledge number = 2

Good grasp of concept - Knowledge of communication appointments which they attended but did not fully understand information being communicated. Knowledge number = 3

Excellent grasp of concept - Knowledge of communication appointments and attended while feeling they fully understood what was being communicated. Knowledge number = 4

Figure 3.12: Focus group perspectives on fracking related communication and quality thereof.

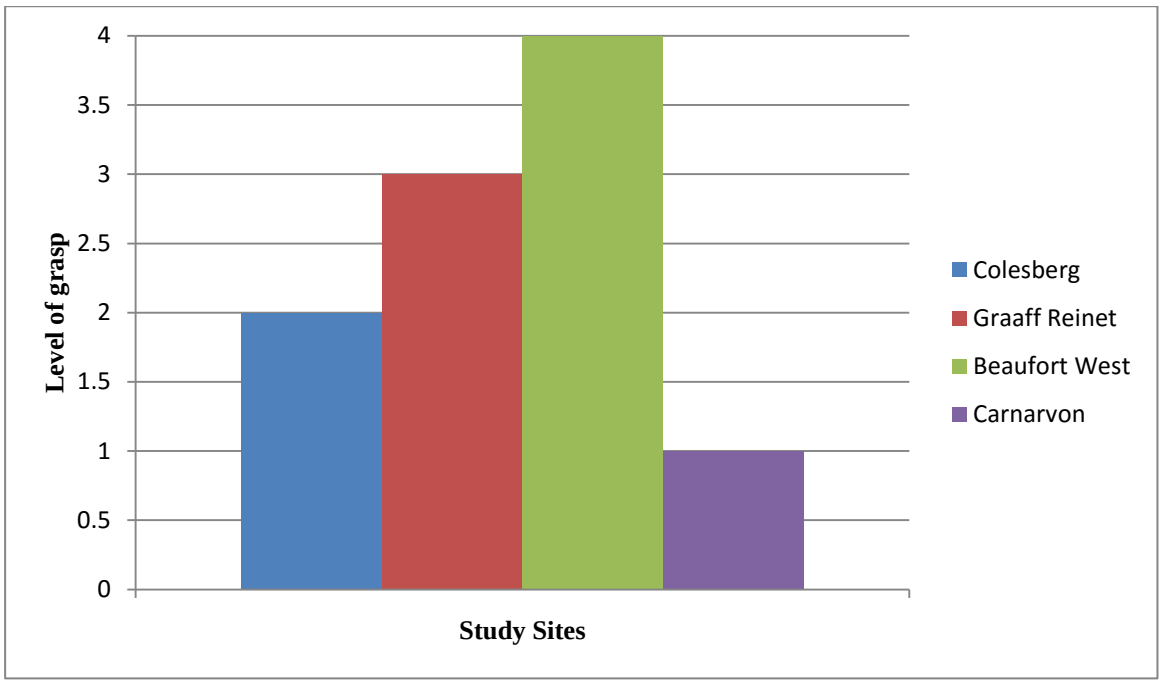
Figure 3.12 indicates that most of the participants have gained most insight and information concerning fracking through media outlets, such as television programs, newspaper articles and activists protesting fracking. Beaufort West, Graaff Reinet and Victoria West had participants who thought that information sessions with the fracking companies were frustrating since the information provided was too scientific to really be understood by the farming and general community. They indicated that they were being overloaded with information that was technically oriented. This made them feel that they could not ask questions that would address concerns they had relating to fracking. Community participants also stated that information presented was very non-specific concerning the chemicals which are used during fracking processes, rehabilitation strategies considered for post-fracking purposes and also employment opportunities for the community. In some cases communities indicated that they were supplied with general information without any specifics, such as information concerning environmental risks. They also found that a lot of the correspondence was repetitive without any further insight into problems relevant to fracking. However, some respondents from Graaff Reinet and Victoria West felt that communication appointments with fracking companies were helpful and they could understand what was being presented and relayed to them.

The communications between community and fracking companies were mostly deemed repetitive and some what vague by the majority of respondents. Although the quality of information communicated could be questioned, it is also important to note some aspects that could have hampered understanding. These aspects include community interest levels in fracking procedures (including lack of interest), timing of the information sessions (during work hours or on Friday afternoons) and educational level of the community (mostly secondary level education) receiving the information concerning fracking. These factors had to be considered, if local government where to ever launch awareness campaigns relating to fracking in Nama Karoo towns.

It is crucial to establish if government and government officials have communicated fracking information to community members concerning the fracking process and procedures which are expected to be implemented by fracking companies. This line of questioning is intended to give an impression of the existing communication relationship between government officials and communities affected by fracking.

3.5.2 Government opinion of fracking communication with communities

This question can be found in the government questions annexture as question seven. The table below presents the parameters of the question data analysis which is then presented in a bar graph format for each of the participating local government officials.



No grasp of concept - No knowledge of any communication. - Knowledge number = 1

Average grasps of concept - Knowledge of fracking company communication appointments but did not attend. Knowledge number = 2

Good grasp of concept - Knowledge of communication appointments by fracking companies which they attended but did not fully understand information being communicated by fracking company. Knowledge number = 3

Excellent grasp of concept - Knowledge of communication appointments by fracking companies and attended while feeling they fully understood what was being communicated by fracking company. Knowledge number = 4

Figure 3.13: Local government perspective on community related communication concerning fracking.

Figure 3.13 indicates that local government officials from Carnarvon stated that they did not even know that their town has been included in the prospected fracking zone and that they have not received any communication concerning fracking from anyone. Consequently, they had no information to relay to communities. Government officials from Colesberg compiled a panel of local and regional government officials who contacted the fracking companies and asked them to organise information sessions concerning fracking and fracking prospects. They took it upon themselves to arrange the meetings between panels of government representatives. These were closed meetings and the information discussed was not communicated with the community at large. The government officials from Graaff Reinet did not communicate directly with the community concerning fracking. Instead they joined the meetings organised by fracking companies as participants alongside the community. Their role during these meetings was to ensure that everyone in Graaff Reinet was invited to the meetings and that meetings continued in an orderly fashion. Regarding these meetings a government official from Graaff Reinet stated:

"*A lot of people stopped coming to meetings after the first meeting. Fracking companies should try to elaborate their explanations more since there is still a level of uncertainty concerning fracking*".

The government official from Beaufort West felt that public participation did not take place properly and that public meetings were held quietly and therefore the process which they followed was extremely questionable. The government official from Beaufort West added that there has been an instance, where fracking companies scheduled a formal meeting and then the community never showed up. The Beaufort West local government has also not been able to communicate with the community, because in essence they were at the same knowledge level concerning fracking as the community.

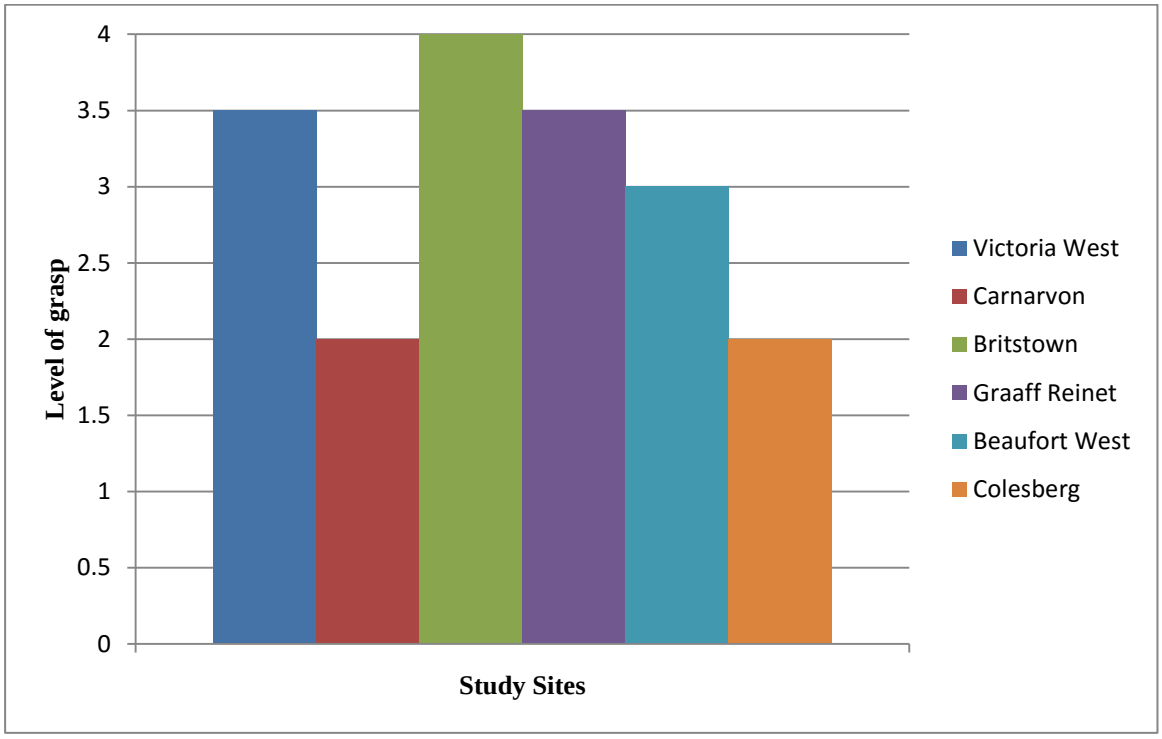
The responses from local government officials and responses from organised community groups were very similar. For the most part both sets of respondents felt that communication between groups has been hampered due to lack of clear information on fracking and related risks. In some instances local governments pro-actively tried to improve the level of understanding and communication on fracking by approaching fracking companies for information. However, the information gained from this interaction has not been made available to the community at large. Since communication forms the foundation of any risk reduction, early warning and awareness strategy, much still needs to be done in the Nama Karoo to communicate information concerning risk and risk reduction strategies related to fracking. More information, correspondence and communication are needed between fracking companies, local government and communities. Once communication issues were addressed local municipalities could initiate education, public awareness and research, concerning fracking and its influences on the Nama Karoo. The following Section 3.6 contextualises these issues which are related to Enabler 2 of the SA NDMF.

3.6 Enabler 2: Education, training, public awareness and research

Enabler 2, addresses the DRM priorities specifically in education, training, public awareness, and research. It describes mechanisms for the development of education and training programmes for disaster management and associated professions along with incorporating relevant aspects of DRM in public awareness programs. In essence this enabler tries to promote and support a broad-based culture of risk avoidance (SA NDMF, 2005). It therefore stands to reason that communities should be informed and trained concerning fracking, risk associated with fracking and how local government deals with consequences (local disaster management representatives), and the fracking companies. Comprehensive communication between government, fracking companies and communities is imperative to ensure risk avoidance behaviour is facilitated in communities in the Nama Karoo. Based on the rational for Enabler two the following questions were directed at the community and government respondents. The first question aimed to determine whether participants have an understanding of the term “fracking” and whether they understand the processes associated with fracking. This indicated if there has been any public awareness and training on fracking, and what the source of participant knowledge is.

3.6.1 Community understanding of the term fracking and the related processes

This question can be found in the community questions annexture as question one. The table below presents the parameters of the question data analysis which is then presented in a bar graph format for each of the participating towns.



No grasp of concept - Does not know what Fracking is, or that they are planning it for South Africa. Knowledge number = 1

Average grasp of concept - Gained information concerning fracking from watching TV, media or reading newspapers. Knowledge number = 2

Good grasp of concept - Community has been informed about fracking but seems unsure of some facts. Knowledge number = 3

Excellent grasp of concept - Community is well informed with facts and extra research they gained themselves. Knowledge number = 4

Figure 3.14: Focus group understanding of the term "fracking" and the fracking process.

Figure 3.14 above indicates that all the communities had some level of grasp on what fracking is. The respondents from Britstown, Carnarvon and Colesberg only gained information concerning fracking from the television and other media outlets. Neither the local municipality nor fracking companies held information sessions in these towns. The lack of proper knowledge was considered a notable problem by the participants. These communities also indicated that they feel that fracking companies might try to bypass community forums and information sessions. They further indicated that bypassing these public forums, fracking companies could potentially put them in a position where they would not have sufficient understanding of the risks they face, how to manage the risks and how to react if fracking has adverse

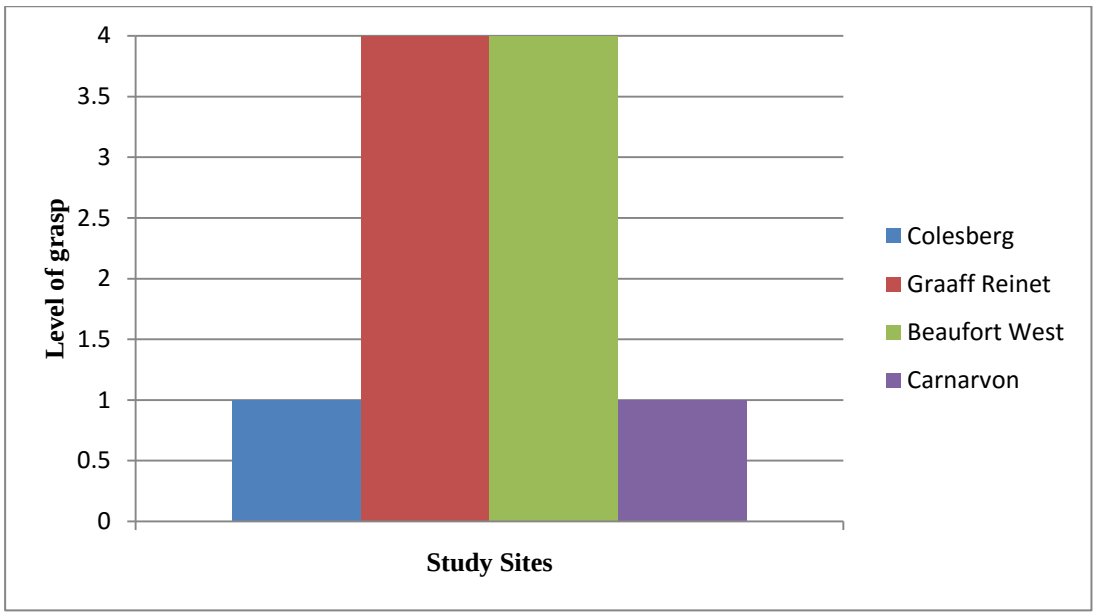
effects. The lack of awareness has created the need amongst participants to know how their livelihoods could be affected by fracking, since they only have one form of livelihood (mostly farming). The participants also expressed concerns about not being aware that they were situated within the proposed fracking zones. Most of these participants were under the impression that they would not be affected by fracking, and that if fracking occurred in the next district they would not be affected by adverse effects coupled with fracking.

Responses from Beaufort West, Graaff Reinet and Victoria West indicated that there is a deeper understanding of fracking due to information sessions, correspondence between fracking companies and the community, and also independent research done by communities. This deeper understanding also stems from some fracking companies specifically organising information sessions with communities and local governments, since they want to initiate exploration in these areas. These communities did however express concerns that they obtain the same information from information sessions presented by fracking companies. This was especially the case with information that addressed the concerns communities have raised in the past (as this information is not forthcoming). These communities also voiced their need to know exactly what fracking companies plan on adding to the water to form the 1% of fracking chemical fluid. The companies were vague in this regard even though this is the most notable concern raised within all the communities. All of the communities indicated that they wanted more and better information. Some communities have, however, done their own research in this regard.

The results show that there is a lack in uniform distribution of fracking knowledge and public awareness in the Nama Karoo. This lack of uniformity was concerning since all the towns within this study fall into, or are close to the proposed sections (as shown in Figure 1.1 and 1.2) for fracking in the Nama Karoo. If public awareness does not improve in the whole of the Nama Karoo, communities and local government would not have the opportunity to understand and do research concerning fracking risk prior to fracking implementation. This in turn adversely affects their ability to mitigate or reduce their disaster risk related to fracking. The local government also had the opportunity to respond to what their understanding is of the term fracking and fracking processes. It is crucial to gain insight into government officials' understanding of fracking since their knowledge would be the foundation of any public awareness program. The response from government concerning this question is presented below.

3.6.2 Government understanding of the term fracking and the related processes

This question can be found in the government questions annexture as question one. The table below presents the parameters of the question data analysis which is then presented in a bar graph format for each of the participating local government officials.



No grasp of concept - Does not know what Fracking is or that they are planning it for South Africa. Knowledge number = 1

Average grasp of concept - Gained information concerning fracking from watching TV, media or reading newspapers. Knowledge number = 2

Good grasp of concept - Government has been informed about fracking but seems unsure of some facts. Knowledge number = 3

Excellent grasp of concept - Government is well informed with facts and waiting for further instruction from National government. Knowledge number = 4

Figure 3.15: Local government understanding of the term "fracking" and the fracking process.

Figure 3.15 indicates that local government officials from Carnarvon and Colesberg who took part in the study were not knowledgeable of what fracking is at all. They only knew that it had something to do with mining, but did not know exactly how it would work or what risks were associated with the process. The Graaff Reinet government official indicated that he has been asked to draft a possible disaster plan in case fracking exploration took place and it had environmental repercussions. Because of this disaster plan that needed to be drafted, an in-depth study and collaboration with the community was needed to gain knowledge concerning fracking in South Africa. The Beaufort West government official presented a PowerPoint presentation which had been presented to the Western Cape government concerning fracking, and what fracking companies have communicated concerning the process thus far. This PowerPoint presentation showed all the intricate fracking processes underground with the fluid mixture, without specifying the chemicals used during the fracking process.

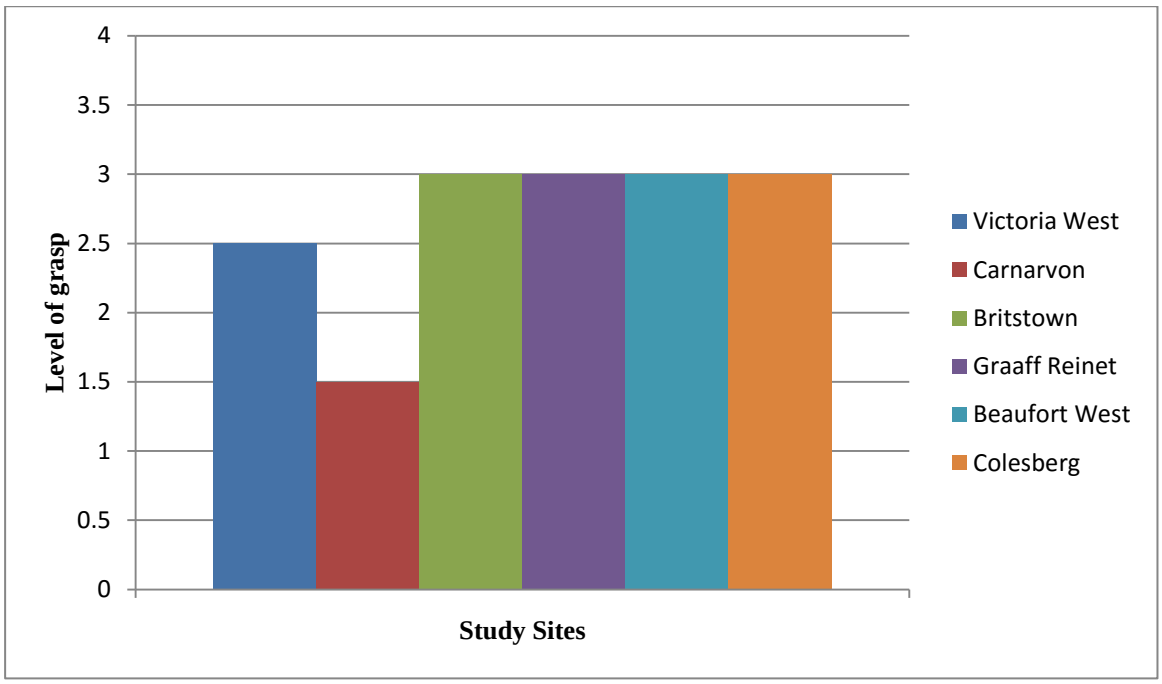
The knowledge of town officials with regard to fracking was vastly different between towns. Respondents from Beaufort West and Graaff Reinet had a more in-depth understanding of fracking and the processes related to fracking since they have been required to do presentations and draw up disaster plans incorporating fracking. This basic knowledge would aid the formulation of public awareness

programs for these specific towns. Carnarvon and Colesberg government officials, on the other hand, only gathered knowledge from media outlets concerning fracking and they only showed a very basic knowledge of what fracking was and what it entailed. This illustrated that, similar to the communities, there was a non-uniform distribution of fracking knowledge and government awareness of fracking and its processes. Public and local government awareness concerning fracking and fracking processes needs to be addressed to ensure comprehensive actions taken and ensuring inclusive disaster risk assessment, mitigation strategies and capacity building initiatives. In terms of improving public awareness amongst key stakeholders, DMAF can be set up (in line with KPA 1). These forums can invite government officials and community members that have an in-depth knowledge of fracking, and use their expertise to improve the overall understanding of fracking and its risk for the Nama Karoo.

The next question relevant to Enabler 2 required communities to relay their opinions on the possible environmental impacts fracking could cause. This also served to indicate if respondents have been made aware of fracking risk by local government or fracking companies.

3.6.3 Community opinion on environmental impacts associated with fracking

This question can be found in the community questions annexture as question two. The table below presents the parameters of the question data analysis which is then presented in a bar graph format for each of the participating towns.



No grasp of concept - Does not know what an environmental impact is with an illogical opinion. Knowledge number = 1

Average grasp of concept - Knows what an environmental impact is without an opinion. Knowledge number = 2

Good grasp of concept - Good opinion that makes sense and knows what an environmental impact is. Knowledge number = 3

Excellent grasp of concept - Knows exactly what environmental impacts are with a solid opinion with examples. Knowledge number = 4

Figure 3.16: Focus group perspectives on the environmental impacts of fracking.

Figure 3.16 indicates that respondents from Britstown, Carnarvon and Graaff Reinet were not sure which environmental impacts fracking could have. They were unsure on the matter and they indicated that they did not know enough about fracking to be able to voice an opinion. There were also some participants in Carnarvon, Graaff Reinet and Victoria West who knew what environmental impacts were, but felt that they needed more information concerning fracking to be able to fully understand what the impacts were. They also indicated that they could not be sure about the quality of information since this came to them in a form of hear-say from other community members, and not technical experts.

Some participants from Beaufort West, Britstown, Colesberg and Victoria West indicated a solid knowledge base and understanding of environmental impacts related to fracking, to such an extent that they had their own opinions on how fracking could affect the environment of the Nama Karoo. They stated that their areas were very dependent on groundwater resources and that if fracking somehow pollutes the groundwater system, their farming practices and businesses (livelihoods) would be adversely affected. If the groundwater is polluted, the surrounding environment could be affected since the fauna and flora in the area would perish if soil is polluted by polluted water. They believed that if this scenario became a reality it would put their lives and livelihoods at risk, which was a concern for DRM. It was

also further stated that an increase in traffic on dirt roads, or new dirt roads could scar the veldt irrevocably for, approximately, the next 50 to 100 years. The farmers and business forums estimated that this (50 to 100 years), would approximately be the time it would take for their ecosystem to rehabilitate naturally.

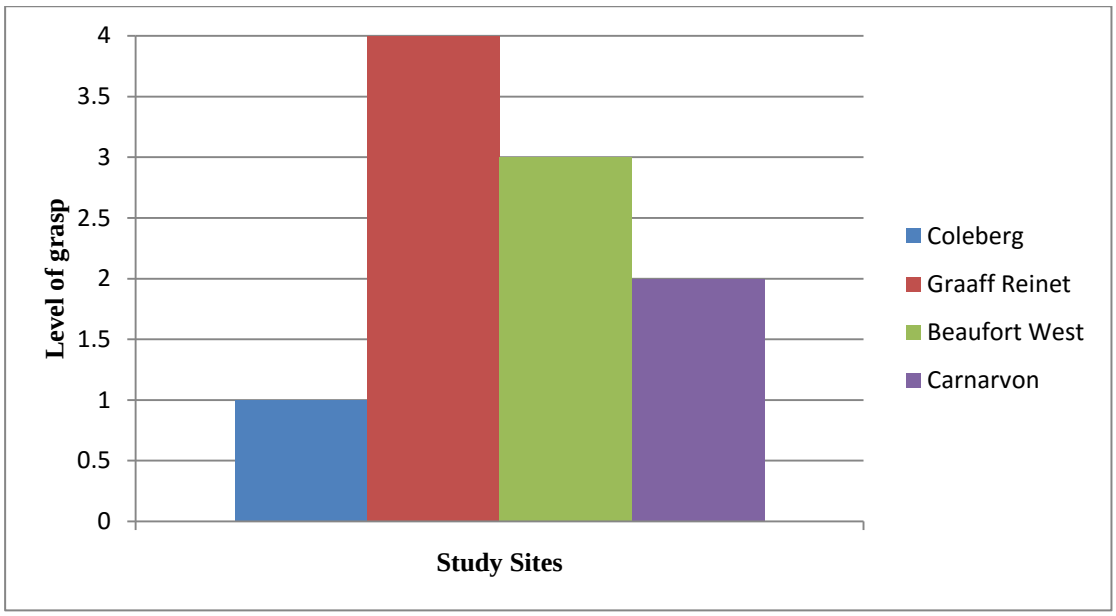
In Britstown and Graaff Reinet some respondents knew exactly what environmental impacts of fracking were. This was substantiated through opinions and practical examples related to environmental impacts of fracking. The community participants indicated that they felt fracking companies would do whatever they deemed necessary, and that the community could do nothing concerning this environmental exploitation, since this exploitation would be funded through bribery of government officials. Concerns were also furthermore expressed that neighbouring farmers might rent out pieces of land for fracking and that the fracking towers could potentially drill horizontally into their farming areas. This would consequently pollute their groundwater sources without the fracking towers having gained permission from them to access their farming areas. The farmers also raised the issue that employees from fracking towers would be travelling through their farms to the fracking towers and they might steal from them or vandalise their property.

The majority of community participants did show some understanding of possible environmental impacts of fracking. Interview responses, however, indicated that the understanding was not facilitated by public awareness projects. The knowledge was generated through their own research or meetings between civil society actors.

Local government was asked to identify the environmental impacts of fracking. The aim of asking government to give an opinion on environmental impacts of fracking was to ascertain if local government and community representatives shared the same concerns related to environmental impacts of fracking and fracking processes. Discovering what the concerns were of government (compared to communities) was important for public awareness endeavours as envisaged by Enabler 2. Differences or similarities relating to concerns would determine the content of awareness campaigns and could lead to long term success, or failure of these campaigns.

3.6.3 Government opinion on the environmental impacts associated with fracking

This question can be found in the government questions annexture as question two. The table below presents the parameters of the question data analysis which is then presented in a bar graph format for each of the participating local government officials.



No grasp of concept - Does not know what an environmental impact is with an illogical or no opinion. Knowledge number = 1

Average grasp of concept - Knows what an environmental impact is without an opinion. Knowledge number = 2

Good grasp of concept - Good opinion that makes sense and knows what an environmental impact is. Knowledge number = 3

Excellent grasp of concept - Knows exactly what environmental impacts are with a solid opinion with examples. Knowledge number = 4

Figure 3.17: Local government perspective on the environmental impacts of fracking.

Figure 3.17 indicates that local government officials from Colesberg declined to answer this question, since they felt that they were not properly informed concerning the processes implemented during the fracking processes. Therefore, they could not present information to communities they were not privy to. The Carnarvon government official stated that although he was not sure how fracking worked, most mines polluted water and the environment, and therefore he indicated that he believed that this would be the case for fracking and its processes as well. The government official from Graaff Reinet stated that fracking could destroy the environment on which people depended for their lives and livelihoods. This government official indicated that fracking companies admitted that there is a chance of water pollution during the process and he also indicated that this would be a notable problem for their town, since the town is situated in a water scarce area. The Beaufort West government official indicated that Merweville (which is a town within the Beaufort West local municipality) already had a borehole which could be ignited due to its gas content and this was the case even before fracking commenced. The government official was also concerned about rehabilitation of the environment after fracking commenced, coupled with adverse environmental influences.

From the above responses it became clear that government officials have their suspicions concerning what possible environmental impacts of fracking could be on their communities. However, the

knowledge they had on the subject, seemed to be a personal opinion instead of a researched or informed opinion. Considering this, communities felt that they had very limited understanding of possible fracking impacts and it would therefore be crucial for government officials to formulate an official research strategy to investigate fracking risks, which in turn could be integrated into a more comprehensive public awareness strategy in affected communities.

3.7 Conclusion

All of the SA NDMF KPAs and Enablers relevant to this study for a comprehensive analysis of the research data have been contextualised and various research questions were assigned to their relevant KPAs or Enablers. Each question was discussed in the context of relevant KPAs and Enablers to identify any differences in organised community groups and local government perspectives. The highlighted differences in perspectives were coupled with long and short term advantages and disadvantages of fracking, as indicated by local government and organised community group participants. Local government participants tended to focus more on short term, and specifically monetary, advantages and disadvantages. The organised community groups indicated long term advantages, (specifically relevant to livelihoods, groundwater and environmental pollution), and disadvantages were coupled with short term economic and population growth aspects. Furthermore the research indicated a uniform unequal distribution of fracking related information within the various towns of the Nama Karoo. The local government and local community group interviews gave an indication of the non-uniform distribution of fracking knowledge or the complete lack of fracking related knowledge in some cases. These differences in perspectives give way to relevant recommendations being made and conclusions being drawn up based on the data analysis.

CHAPTER 4 CONCLUSIONS AND RECOMMENDATIONS

4.1 Introduction

During this study the research questions were answered and research objectives reached. The research questions and objectives were firstly addressed in Chapter 2 by providing: a theoretical foundation of fracking in fragile ecosystems (the Nama Karoo); how fracking could affect the livelihood of inhabitants of the Nama Karoo; and how the DMA and SA NDMF are structured to deal with disaster risks associated with fracking. The SA NDMF KPAs and Enablers were then contextualised in Section 2.5 to draw parallels between environmental protection, groundwater management, and livelihood in the Nama Karoo. Furthermore in Section 2.5 the scope of the SA NDMF was indicated by discussing relevant KPAs and Enablers for this study. The theory contextualised in Chapter 2 was then incorporated into Chapter 3 which presented the data. The research question data was assigned to their relevant KPA and Enabler counterparts to ensure that the data was discussed in accordance with the parameters discussed in Section 2.5 of this document. These parameters guided the data analysis by contextualising what the SA NDMF required for comprehensive disaster management plans and which specified actions are therefore necessary. Within the data context, various differences were identified and discussed with relation to local government and organised community group responses to the research questions. Along with the identified differences in responses the similarities of responses during research was also given cognisance.

During this chapter the research questions and objectives (as per Sections1.3 and 1.4) are used as indicators for research recommendations. These questions and objectives are also discussed in relation to the data presented in Chapters 2 and 3, to indicate the importance of addressing issues related to differences in responses gained from local government and organised community groups. The differences in these responses give a clear indication of where discrepancies were found between the theories presented in Chapter 2, and specifically Section 2.5, and correlated data in Chapter 3. The first parameter in the recommendation phase, though, is to conceptualise challenges identified and addressed by Texas and Australia to ensure that South Africa does not make similar mistakes when fracking is implemented in the Nama Karoo. This was done based on research question one which focused on what the theoretical foundation of hydraulic fracking is along with impacts thereof on the environment.

4.2 The theoretical foundation of hydraulic fracking and the impacts thereof on the environment

The objective of this research question was to determine the theoretical foundation of hydraulic fracking and impacts thereof on the environment. The theoretical foundations and assumptions based on Texas

and Australia case studies are contextualised below. This research question further relates to Sections 1.1.1, 1.1.2, 2.1.1, 2.1.2 and 2.1.3, where fracking is theoretically contextualised along with the environmental impacts associated with fracking, and also Sections 2.2 and 2.3 which contextualise the challenges and issues addressed in Texas and Australia. Flowback treatments and uses were then discussed to ensure that relevant recommendations were presented, relevant to this specific research question.

4.2.1 Recommendations based on case studies – Texas and Australia

Since Texas in the USA and Australia have been fracking for a few years, their trials and errors would be useful in establishing a guideline for South African legislation (Zillman *et al.*, 2015). Arguments have been made that proper control and legislation can limit the impact of fracking on the environment, although these measures will not completely eliminate it (Danielle *et al.*, 2013).

The relevant legislation and control practices were amended to include a chemical risk assessment pertaining to hydro fracturing which assesses the level of potential impact that fracking and the resulting flowback could have on the environment, groundwater and livelihood (Medina & Suedel, 2015). Effective treatment solutions to flowback have been tailored to meet specific re-use goals based on legislation requirements. The composition of flowback water is of importance when trying to implement suitable treatment procedures and ensure water re-use sustainability (Lester *et al.*, 2015). The necessary flowback treatment is determined by the quality of raw flowback water, as well as intended use of the end product. The two existing options for flowback treatments are, recycling for future fracking use or for re-use outside the gas industry (Lester *et al.*, 2015).

A conceptual model has been developed by USEPA, to promote a general understanding of the hydro fracturing process. This conceptual process indicates how the process theoretically works and what the resultant effects are (Medina & Suedel, 2015). Research done by government has shown that fracking produces little, or no harmful effects to underground drinking water, although the possibilities of increasing environmental regulations are still being explored in light of fissure and fracture extent, which cannot be determined prior, during or after fracking processes (Willis, 2013).

In conclusion the resultant environmental amendments made in Texas and Australia led to intensified environmental and groundwater legislation, which directly indicated how fracking needed to be managed, how flowback needed to be handled, and also where fracking was allowed in relation to community settlements. The fact that Texas and Australia felt the need to incorporate these measures into their legislative frameworks indicated that fracking practices had adverse effects on regions surrounding the areas subjected to fracking procedures. These measures would need to be drawn up and taken into consideration by the South African Disaster Management to ensure that basic fracking risks could be

identified and addressed within the disaster management plans for the Nama Karoo. Addressing these risks before fracking commences allows the SA NDMF to manage risks associated with fracking more effectively, and disaster response related to fracking is done more efficiently.

The risks associated with fracking were indicated during the research in Sections 1.1.1, 2.1.2 and 2.1.3. One of the main risks indicated pertains to the large amounts of water the fracking process requires. Due to the water intensive nature of fracking and possible adverse effects of fracking on the environment, water re-use and flowback treatment options for fracking has been explored.

4.3 Demonstrate which sections of the Disaster Management Act (DMA) and the National Disaster Management Framework (SA NDMF) pertain to successfully manage the environment, groundwater and livelihood risk increases coupled with fracking implementation in the Nama Karoo

This research question objective is to determine which sections of the DMA and SA NDMF pertain to successfully managing the environment, groundwater and livelihood risk increases coupled with fracking implementation in the Nama Karoo. The DMA and SA NDMF structures relevant to this study were contextualised in Chapter 2 Sections 2.4 and 2.5. Within the next sections a short summary of the Chapter 3 research findings are presented.

4.3.1 Disaster Management Act (DMA)

The purpose of the DMA (contextualised in Section 2.4) is to act as a guideline for disaster management implementation. The aim of the DMA is to sustain, commit and enable concerted efforts made with regard to disaster risk management reform by government, along with a wide range of stakeholders as reflected within the DMA. The DMA therefore provided an integrated and co-ordinated disaster risk management policy that focused on preventing or reducing risks associated with disasters, disaster severity mitigation and preparedness, as well as rapid and effective response to disasters. The DMA also recognised the need to establish national, provincial and municipal disaster management centres, obtaining disaster risk management volunteers and other challenges relating to these issues. All DMA requirements are addressed within the SA NDMF since this framework was created to support the DMA. Within the following sections the SA NDMF KPAs and Enablers are discussed with relevance to the research findings of Chapter 3.

4.3.2 KPA 1: Institutional arrangements for DRM

Under KPA 1 (contextualised in Sections 2.5.1 and 3.2), it has been found that there is a lack of DMAF between communities, Shell and the local government. The diverse opinions obtained from community focus groups, Shell information handout copies and local government interviews hold specific challenges concerning how institutional arrangement for DRM could be addressed to be able to manage fracking risk. It is imperative that DMAF include participants from both pro-fracking lobbyists and anti-fracking lobbyists. The compilation of these various parties enables a balance to be found between perceived benefits of fracking and the perceived adverse effects thereof. This holistic approach enables uniform disaster management and contingency plans to be created. The holistic approach also allows the DMAF to address fracking risks more comprehensively. The issues hampering a holistic approach are thus far coupled with community participants and local government officials not being able to suggest environmental or DRM contingency plans, relating directly or indirectly to fracking. An institutional mechanism such as a DMAF would provide a safe platform for environmental oversight roles to be established, thereby providing participants with the necessary platform to obtain extensive insight into possible environmental effects of fracking. The DMAF also makes provision for role-players and community members to present their input and advice concerning various topics discussed related to fracking. The aim of the DMAF is therefore, to draw up comprehensive disaster management plans specifically focussing on fracking risks (water pollution, environmental pollution and disaster risk) which were identified during a detailed risk assessment. The available institutional structures do not pertain to fracking per se and this could have a detrimental impact on the DRM function contextualised within the SA NDMF. Human resource shortages need to be addressed since these shortages would further hamper the DRM function in the Nama Karoo. The local government acknowledges the need for DRM structures since DRR relies on a DMAF or similar platform.

4.3.3 KPA 2: Disaster Risk Assessment

The questions relevant to KPA 2 (contextualised in Sections 2.5.2 and 3.3), indicated that there was a difference in perceived duration pertaining to the considered advantages coupled with fracking. The economic advantages surrounding fracking is considered to be short term, whereas the main focus addresses long term pollution coupled with the fracking process. Local government responses mostly focussed on economic benefits to their community. The long term focus highlighted economic, social and environmental vulnerabilities, coupled with fracking. The long term vulnerabilities were highlighted by the organised community groups. These vulnerabilities that communities indicated could therefore cause long term livelihood harm or loss if fracking risks were not addressed through management. It is therefore clear that fracking risks should be addressed in a holistic way, by incorporating positive (capacities) and negative (vulnerability and risk) impacts of fracking. Compiling an in-depth disaster risk

assessment, it is important to take note of both the short- and long-term risk perspectives to ensure that successful DRR methods are applied.

4.3.4 KPA 3: Disaster Risk Reduction (DRR)

Responses relevant to KPA 3 (contextualised in Sections 2.5.3 and 3.4) questions indicated that organised community groups highlighted the fact that contingency plans were lacking. The organised community groups also indicated that they need more information to draw up, and implement contingency plans for the various local businesses when fracking commences. Some of the towns (Beaufort West, Graaff Reinet and Victoria West) have DRR and contingency strategies in place concerning fracking. Only these three towns have DRR methods in place, while other towns who participated in the study have no concrete contingency plans in place for fracking or any other form of disaster. They could only provide IDP structures which do not replace a comprehensive disaster management plan. A proper briefing is needed concerning fracking risks and relevant disaster management plans for DRR methods to be successful in the Nama Karoo. After the DRR strategies have been formulated it is crucial to distribute information concerning fracking risks and methods to multiple stakeholders such as town councils, all spheres of government, Shell (implementing fracking processes) and affected communities in the Nama Karoo. Enabler 1 addresses the distribution of information concerning DRR strategies and DRM.

4.3.5 Enabler 1: Information management and communication

The questions coupled with Enabler 1 (contextualised in Sections 2.5.4 and 3.5), indicated that communication between communities, local government and Shell have become repetitive and vague, if communication occurred at all. There are aspects that could hamper the understanding of communicated information such as: community interest levels in fracking; timing of information sessions; and the educational level of the community receiving fracking information. The fracking awareness campaigns need to take these aspects into consideration to ensure effective communication. The responses from local government officials and organised community groups are similar concerning communication received from Shell. All of the respondents from local government and organised community groups indicated that communication is hampered due to lack of clear information concerning fracking and related risks involved. Colesberg local government tried to pro-actively improve their level of understanding and communication distributed concerning fracking by approaching Shell for information. This pro-active interaction to gain access to fracking related information has not been made public. Information concerning risk and risk reduction strategies relating to fracking needs communication which forms the foundation of any risk reduction, early warning or awareness strategy. Comprehensive information, correspondence and communication are needed between Shell, local government and

affected communities. When these communication issues are addressed, the local governments can initiate a comprehensive education, public awareness and research campaign concerning fracking and influences fracking can have on the Nama Karoo.

4.3.6 Enabler 2: Education, training, public awareness and research

The questions pertaining to Enabler 2 (contextualised in Sections 2.5.5 and 3.6) indicated that there was a lack in uniform distribution of fracking knowledge and public awareness in the Nama Karoo. This is concerning since all the researched towns fall into or are in close vicinity of the prospected fracking section as indicated in Figure 1.1 and Figure 1.2. Public awareness needs to be improved to allow communities the opportunity to understand fracking, and research needs to be done concerning fracking risks, prior to fracking implementation. The lack of public awareness could adversely affect community ability to mitigate or reduce their disaster risk, caused by fracking implementation. There is a vast difference in fracking knowledge under local government officials. This vast difference in knowledge distribution under local government officials is similar to the non-uniform distribution under researched organised community groups. These differences in fracking knowledge need to be addressed to ensure uniform distribution of fracking knowledge between the communities and local government officials of the Nama Karoo. Addressing this issue ensures more comprehensive actions taken to ensure inclusive disaster risk assessment, mitigation strategies and capacity building initiatives through the whole Nama Karoo. The initial point of departure to address the issue would be to set up DMAF in line with KPA 1. These forums are able to invite the government officials and community members who have an in depth knowledge of fracking, to use their expertise to improve overall understanding of fracking and related risks for the Nama Karoo. The understanding of possible environmental impacts indicated by participating communities and local government officials indicated that the coupled understanding does not originate from public awareness projects. The knowledge presented during the interviews was generated through research or meetings between civil society actors and media resources.

The recognised challenges during the research, coupled with various SA NDMF KPAs and Enablers, indicated various issues which need to be addressed. Some of these issues can only be addressed by government, for example, to have up to date disaster management plans, comprehensive risk assessment strategies and DRR strategies in place for fracking. Other issues can be addressed through the use of a DMAF which addresses key community, local government and Shell fracking issues and provides a platform for role-players to participate in disaster risk management. The identified challenges are somewhat addressed within the disaster management plan recommendation section below.

4.3.7 SA NDMF Local, Provincial and National Disaster Management Plan recommendations

The SA NDMF KPAs and Enablers discussed in Sections 2.5.1, 2.5.2, 2.5.3, 2.5.4 and 2.5.5, contextualised parameters and prerequisites for implementing the SA NDMF. These parameters were then correlated in Chapter 3 with the various relevant research questions to ascertain whether or not the prerequisites were implemented comprehensively in the Nama Karoo (summarized in Sections4.3.2, 4.3.3, 4.3.4, 4.3.5 and 4.3.6). The data showed that there were discrepancies in the implementation of various KPAs and Enablers. The only way to address this issue is for local government to revisit the KPA and Enabler parameters, and to start uniformly implementing them as required with relation to fracking, further enabling the move from level one disaster management plans through to level three disaster management plans. Local governments need to establish a DMAF and also needs to initiate a disaster risk assessment pertaining specifically to fracking and its processes. Local government is also responsible for proposing disaster risk reduction strategies and implementation thereof with specific relation to fracking risks and fracking processes. These recommendations are based on the parameters of KPAs in the SA NDMF. Furthermore local government needs to establish a line of communication with Shell to gain access to fracking information. This aids local government to improve information management and communication directly relevant to fracking. Lastly local government is responsible for creating public awareness in collaboration with Shell to ensure that public awareness and research relevant to fracking is evenly distributed between fracking affected communities within the Nama Karoo. The implementation of these strategies could, in theory, lead to further economic injections and comprehensive disaster management planning in the local communities and governments affected by fracking in the Nama Karoo. These strategies and economic injections would then also address concerns related to sustainable livelihood development and fracking practices.

4.4 Explored and analysed the unique community and local government official's perspectives concerned with disaster risk management due to fracking and their general understanding of fracking through fracking company communications in the Nama Karoo

The objective of this research question was to explore and analyse the unique community and government officials' perspectives, indirectly concerned with disaster risk management, related to fracking in the Nama Karoo. Firstly the impacts of fracking on sustainable livelihoods development are discussed to present the challenges coupled with sustainable livelihood development associated with fracking. The monetary implications of fracking risks are then contextualised.

4.4.1 Sustainable livelihoods development with fracking

Sustainable livelihoods and development can be achieved only if a country's governance structure allows for implementation of public policies that are conducive to economic and social development (Ahrens &

Rudolph, 2006). Sustainable livelihoods are focused on ensuring that more land is in the hands of the rural poor along with skills, financial resources and organisations which are needed to develop, and use rural areas productively and sustainably. This aids rural areas in developing more sustainability, since the rural community would be able to take charge of their own areas and investments within an organisation (Gwanya, 2010). This approach is centred on people, integration and sustainable development which proceed in a democratic and participatory way (Gwanya, 2010). Environmental monitoring and testing during fracking could expand the understanding of risks which are associated with oil and gas development, which would lead to strategies mitigating effects of fracking. The environmental monitoring and testing furthermore assists in establishing a participatory approach to sustainable development of the Nama Karoo (Branscomb, 2013).

The recommendation for this section is to create a DMAF between the community, local government and Shell to enable comprehensive communication between these parties. This DMAF leads to community participation and interest being cultivated concerning fracking. Furthermore a relevant issue for the various parties, relevant to livelihood concerns, can be contextualised and addressed as need therefore arises. The DMAF aids in establishing projects and strategies conducive to sustainable development of the Nama Karoo, and communities and their livelihoods affected by fracking processes. In the case of fracking affecting community livelihoods monetary implications related to environment, groundwater and livelihood losses could be caused. These monetary implications are contextualised in the next section.

4.4.2 Monetary implications coupled with fracking and fracking damages

Monetary and law abidance should be required from the oil and gas industry for fracking operations at every fracking well site. This abide assurance ensures that taxpayers, communities or families do not pay for the damage fracking causes to environment, groundwater and livelihood (Ridlington & Rumpler, 2013). In South Africa a form of moratorium needs to be identified and implemented before fracking starts, to ensure that the Nama Karoo does not experience the same fate as Texas (Leclere, 2014). These recommendations relevant to fracking related damages would need to be discussed in the DMAF. The DMAF would need to compile comprehensive budget estimations, related to fracking disaster risks, to allow a monetary value to be allocated to various coupled disaster risks. If the SA NDMF compiles a comprehensive disaster risk list, based on a risk assessment of fracking influences on the Nama Karoo, the budget allocates an estimated monetary value to possible future fracking disasters. This monetary value needs to be addressed by Shell in the form of initiating a fracking disaster risk trust fund to ensure that local government and community has access to the funds in case of fracking related disasters. The DMAF and Shell would need to advise on viable candidates from affected communities, local governments and Shell to act as panel representatives managing this fracking disaster risk trust fund, to ensure transparency and fair decision making practices concerning allocation of fracking related disaster

funding. A further recommendation would be that representatives within or close to the DMAF would not be considered as candidates for the panel managing the fracking disaster trust fund.

4.5 Recommendations to fracking affected organised community groups and local government with regards to the management of potential disaster risk due to prospected fracking in the Nama Karoo to enable a proactive disaster management approach

This research questions' objective was to make recommendations with regards to the management of disaster risk due to fracking for further research in the Nama Karoo. Within the various sections discussed in this chapter, recommendations have already been contextualised based on the relevant contextualised topics. Added to those recommendations it would be beneficial for communities and local government from the Nama Karoo to initiate uniform and comprehensive disaster management planning based on the SA NDMF KPAs and Enablers. This allows fracking affected local governments to work in unison to establish relevant institutional arrangements (in line with KPA 1 requirement), enable a more comprehensive disaster risk assessment campaign concerning fracking (in line with KPA 2 requirement), compilation of fracking relevant disaster risk reduction strategies (in line with KPA 3 requirement), improve fracking information management and distribution between local governments, communities and other role players (in line with Enabler 1 requirement), and lastly enable more comprehensive and community relevant education, training, public awareness and research concerning fracking (in line with Enabler 2 requirement). This uniform approach by local government, communities and role players enables a uniform progression between the disaster management plan levels and also builds the regional capacity to enforce said disaster management plans.

4.6 Conclusion

The study focused on disaster risk due to fracking and prospected fracking processes in the fragile ecosystems of the Nama Karoo. The disaster risk was contextualised using a DMA perspective. Chapter 1 gave an introduction and orientation concerning fracking practices and drew parallels between the fracking practices, DMA and SA NDMF guidelines and requirements. Fracking was explained to contextualise what fracking is and how the process of fracking works in theory. The influences of fracking on the economy, environment, groundwater and livelihoods were then explained to indicate how fracking could possibly influence the Nama Karoo and its population. The problem statement contextualised perceived problems for this research study coupled with the relevant research questions and research objectives. The central theoretical statement gave an overview of available information concerning theories surrounding the implementation of fracking in the Nama Karoo. Furthermore assumptions were contextualised and explained based on literature research, and these assumptions

formed a basis for the study. The methodology was explained through use of a literature review, empirical study contextualisation, and explanation of the research setting and sampling for this study, data collection methods used, data analysis strategy, and ethical considerations which were followed during the course of the study. The significance of the study was then explained and lastly a provisional chapter layout was given and followed.

In Chapter 2 the rational for fracking in South Africa was given coupled with an overview of fracking which was contextualised with relation to Section 1.1.1 and 1.1.2. Environmental impacts of fracking were discussed in general and then later related more specifically to hydraulic fracturing and fragile ecosystems – the case of Texas, and also hydraulic fracturing and fragile ecosystems – the case of Australia. The South African Disaster Management Act (DMA) was then contextualised with relation to the DMA: Institutional Structures, DMA: Assessment of Risk, DMA planning and Disaster Risk Reduction practices. After this contextualisation the National Disaster Management Framework (SA NDMF) was discussed with specific focus on KPA 1: Institutional Arrangement for DRM, KPA 2: Disaster Risk Assessment, KPA 3: Disaster Risk Reduction, Enabler 1: Information Management and communication, and lastly Enabler 2: Education, Training, Public awareness and Research.

The third KPA introduces disaster risk management planning and implementation of said plans. Its purpose is to inspire developmentally orientated approaches, plans, programmes and projects that would reduce disaster risks. It also addresses requirements for alignment between disaster management frameworks and development planning within all spheres of government. Furthermore it focuses attention on planning and integration of the core risk reduction principles of prevention and mitigation of ongoing programmes and initiatives (SA NDMF, 2005). This means that disaster risk reduction needs to be incorporated into a developmental project, such as fracking in the Nama Karoo. Consequently all planning surrounding fracking in the area should integrate core risk reduction principles of prevention and mitigation of the ongoing initiatives surrounding fracking process risks.

Enabler 1: Information management and communication, and Enabler 2: Education, training, public awareness and research, which are all relevant to this research study, was then contextualised. Enabler 1 is subsequently discussed since it pertains to KPA 1, 2 and 3 which has been discussed in Section 2.5.1, 2.5.2 and 2.5.3. Enabler 2 is discussed since the information distribution relevant to fracking in the Nama Karoo is sporadic and non-uniform.

During Chapter 3 the research data was presented with the relevant links between research questions and the SA NDMF KPAs and Enablers. The research questions were allocated to their relevant KPA or enabler counterpart for SA NDMF related discussions. The finding for each local government or organised community group research question was presented in the form of a conceptual table coupled with a figure presenting relevant findings. These figures were then discussed in further detail to establish

what the data analysis showed along with how the data linked to relevant KPA or Enabler allocated to the research question at hand.

The context formed in Chapter 2 along with the data analysis findings in Chapter 3, was then used to make relevant and practical recommendations in Chapter 4 of this research study based on the KPA and Enabler requirements. Recommendations were only made relevant to indicated gaps in the research data and research contextualisation. The issues were then addressed through the use of research based contextualisation in Chapter 2 coupled with research findings in Chapter 3 during the data analysis.

This study has reached its research objectives through use of comprehensive theoretical research into fracking and fracking processes, coupled with a qualitative analysis of local government and organised community group participants in the Nama Karoo Biome, which is the area proposed for fracking by Shell.

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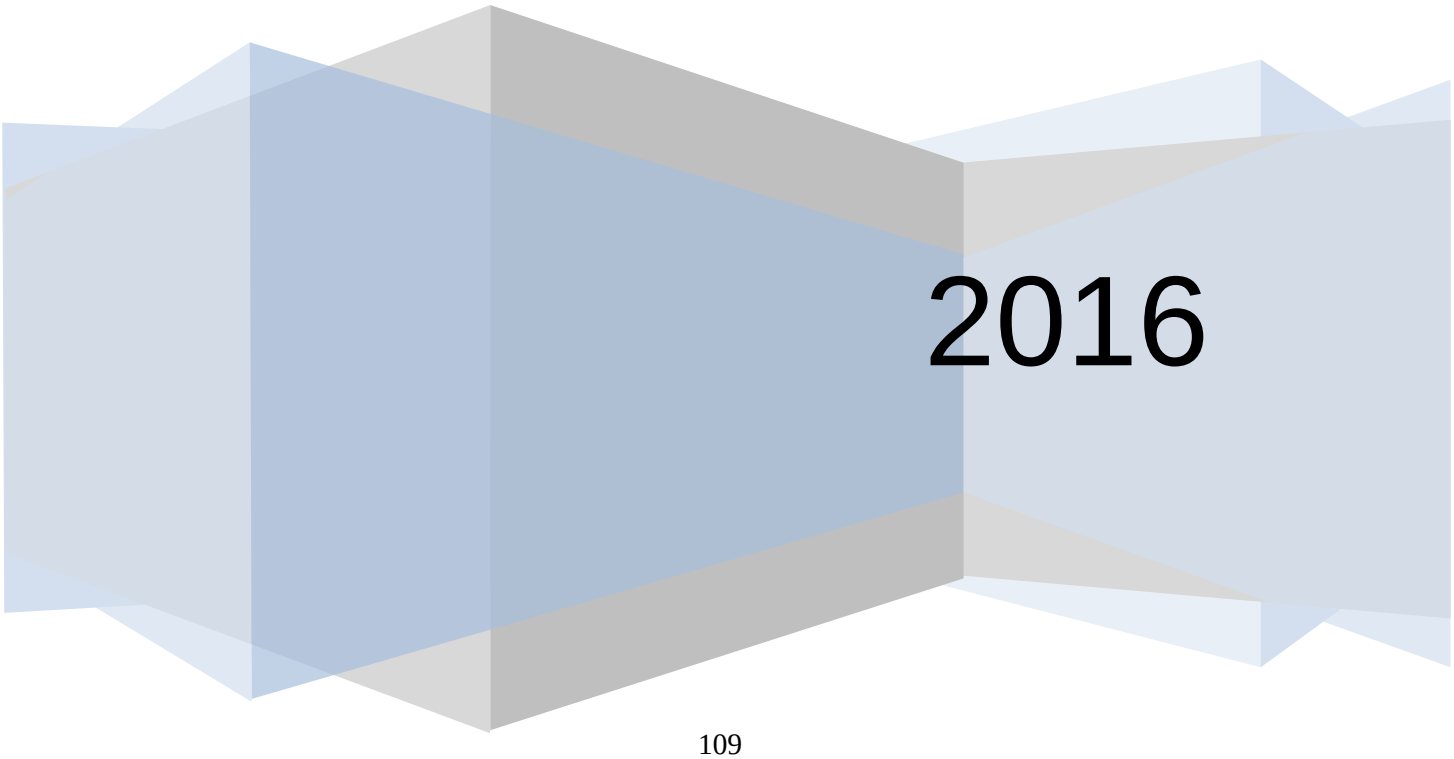
ANNEXTURE A - COMMUNITY QUESTIONS

Disaster risk due to fracking in the fragile ecosystems of the Nama Karoo: A Disaster Risk Management Perspective

Community Questions

African Center for Disaster Studies: Mini Dissertation Questionnaire

Denise van der Merwe



Introduction

This questionnaire is based on an analysis being done concerning fracking and the current environmental procedures in the Nama Karoo area of South Africa. The questions are asked to establish what government officials and organised community groups in Britstown, Victoria West, Beaufort West, Graaff Reinet, Carnarvon and Colesberg know with regard to fracking. This questionnaire does not have a political agenda and the sole purpose of the research is to aid municipalities, government and communities to communicate effectively to ensure that miscommunication is eliminated. The focus is on the environment, groundwater and the current legislation, policies, acts and laws, which are in place in the various research areas.

None of the participants were promised any form of compensation for participation and they were free to stop participating at any point in the interview. The participants were volunteers and therefore may decline to answer questions if they do not feel comfortable to answer a question. The details of participants will not be made public and the confidentiality of answers is ensured. The data obtained by this questionnaire will only be used by the interviewer for analysis and research purposes.

This questionnaire should not take participants more than 45 minutes and participants were encouraged to take their time to answer the questions to ensure that they do not feel rushed. There are eight Government aimed questions and eight Organised Community Group questions.

The provinces and towns being used in this study are primarily Afrikaans speaking and the questions will therefore be translated for the Afrikaans participants and they will also be able to answer in Afrikaans. These answers will then be translated to English for use in this study.

Gemeenskapsvrae/ Community Questions

1. Hoe verstaan u die term ‘fracking’ en wat verstaan u rondom die ‘fracking’ proses? / What is your understanding of the term ‘fracking’ and what do you understand about the ‘fracking’ process thereof?

2. Wat is die moontlike omgewingsimpakte wat ‘fracking’kan hê, na u mening? / In your opinion what will the environmental impacts of ‘fracking’ be?

3. Wat is die moontlike positiewe en negatiewe impakte wat ‘fracking’ op gemeenskappe in ‘fracking’ areas kan he? / What are the positive and negative impacts of ‘fracking’ on communities in ‘fracking’ areas?

4. Watter voorsorgmaatreels sal as besigheid getref word om die omgewingsimpakte van ‘fracking’ te minimaliseer? / What measures will you as a corporation take to minimise the environmental impacts of ‘fracking’?

Uitbreidende vraag / Probe question: Indien ‘fracking’‘n negatiewe impak op die omgewing het, watter planne is in plek om dit te hanteer? / Which contingency plans do you have in place if ‘fracking’ do have a negative impact on environment?

5. Wat word beskou as die voordele van ‘fracking’? / What are the advantages to ‘fracking’?

Uitbreidende vraag / Probe question: Indien daar voordele is met betrekking tot ‘fracking’, hoekom word hierdie aspekte as voordele? / If there are any advantages to ‘fracking’, what are they and why are they seen as advantages?

6. Die Nama Karoo is ‘n water-skaars area. Aangesien ‘fracking’ baie water benodig, watter voorsorgmaatreëls is daarom besoedeling van natuurlike strome, damme en groundwater te minimaliseer? / The Karoo is a water scarce area and ‘fracking’ is linked to water pollution. Whatcontingency plans are in order to minimise the pollution of natural streams, dams and groundwater?

7. Wat is tot dusver aan u gekommunikeer met betrekking tot ‘fracking’? / What communication have you received with regard to ‘fracking’?

Uitbreidende vraag / Probe question: Indien kommunikasie alreeds plaasgevind het, wat was gekommunikeer en hoe voldoende was die inligtingna u mening? / If you have received any communication what has been communicated and how sufficient is the information according to you?

8. Weet u watter wetgewing huidiglik in plek is om die omgewing en grondwater te beskerm? / Do you know which legislations and policies are currently in place, protecting environment and groundwater?

Uitbreidende vraag / Probe question: Weet u of daar enige wetgewing huidiglik bestaan wat slegs gemik is op ‘fracking’? / Do you know if there are currently any policies and legislations specifically with regard to ‘fracking’?

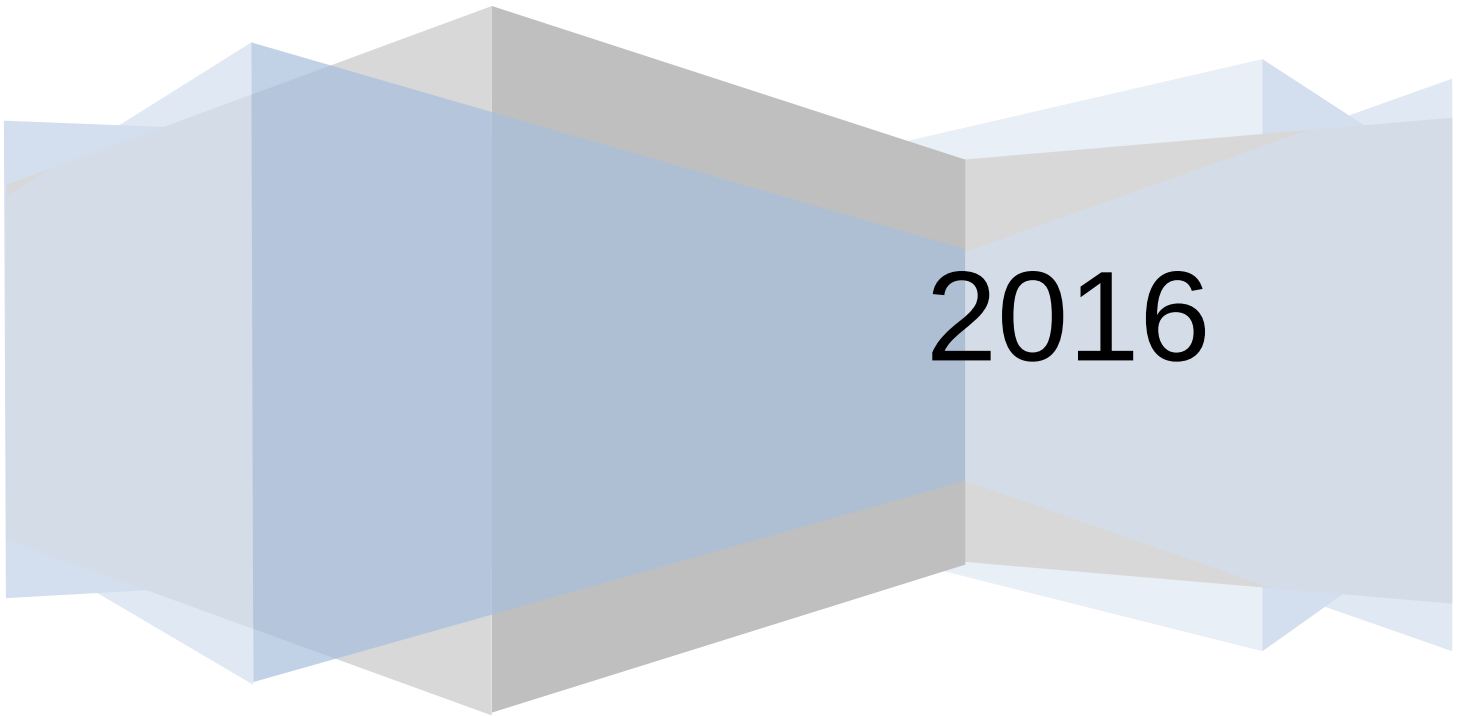
ANNEXTURE B - GOVERNMENT QUESTIONS

Disaster risk due to fracking in the fragile ecosystems of the Nama Karoo: A Disaster Risk Management Perspective

Government Questions

African Center for Disaster Studies: Mini Dissertation Questionnaire

Denise van der Merwe



Introduction

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This questionnaire should not take participants more than 45 minutes and participants were encouraged to take their time to answer the questions to ensure that they do not feel rushed. There are eight Government aimed questions and eight Organised Community Group questions.

The provinces and towns being used in this study are primarily Afrikaans speaking and the questions will therefore be translated for the Afrikaans participants and they will also be able to answer in Afrikaans. These answers will then be translated to English for use in this study.

Munisipaliteitsvrae/ Government Questions

1. Wat verstaan u onder die term ‘fracking’ en die ‘fracking’ proses? / What is your understanding of the term ‘fracking’ and what do you understand about the ‘fracking’ process?

2. Wat is na u mening die omgewingsimpakte wat ‘fracking’ kan hê? / What will the environmental impacts of ‘fracking’ be in your opinion?

3. Wat is die moontlike positiewe en negatiewe impakte wat ‘fracking’ op gemeenskappe in ‘fracking’ areas kan he? / What are the possible positive and negative impacts of ‘fracking’ on communities in ‘fracking’ areas?

4. Watter voorsorgmaatreëls sal die regering/ munisipaliteit tref om die omgewingsimpakte van ‘fracking’ te minimaliseer? / What measures will the government take to minimise the environmental impacts of ‘fracking’?

Uitgebreidende vraag / Probe question: Indien ‘fracking’‘n negatiewe impak op die omgewing het, watter planne is in plek vir die regering/munisipaliteit om dit te hanteer? / Which contingency plans does the government have in place/ mind if ‘fracking’ has a negative impact on the environment?

Uitgebreidende vraag / Probe question: Hoe sal bepaal word of ‘fracking’ waterbesoedeling beïnvloed en watter planne is in plek om besoedeling van water deer ‘fracking’te minimaliseer? / How will ‘fracking’ be linked to water pollution and which contingency plans will be put in place to minimise the pollution of water by ‘fracking’?

5. Die Nama Karoo is ‘n water-skaars area. Aangesien ‘fracking’ baie water benodig, waar sal die munisipaliteit/regering die water vandaan kry vir die ‘fracking’ proses? / The Nama Karoo is a water scarce area and ‘fracking’ is a water intensive process. Where would the government secure water from for this process?

6. Watter wetgewing is in plek om the omgewing en gemeenskappe te beskerm teen besoedeling as gevolg van ‘fracking’? / Which legislative framework would protect the environment and communities from ‘fracking’ pollution?

7. Wat het die munisipaliteit/regering tot dusver gekommunikeer met die gemeenskap met betrekking tot ‘fracking’ en die prosesse rondom ‘fracking’? / What has been communicated to the community by the government, with regard to ‘fracking’ and its processes?

8. Hoe sal u as munisipaliteit/regering verseker dat die wetgewing wat in plek is, gevolg word om die omgewing en die grondwater te beskerm, wanneer ‘fracking’ geïmplementeer word? / How will you as

government monitor and maintain compliance regarding the legislative frameworks which are in place to protect environment and groundwater, when ‘fracking’ is being implemented?

ANNEXTURE C - LETTER OF LANGUAGE EDIT

Language Edit

I, Mariëtte Russell, full member of the Professional Editors' Group of South Africa, hereby declare that I have performed an English language edit on the final version of the dissertation on "Disaster risk due to fracking in the fragile ecosystems of the Nama Karoo: A Disaster Risk Management Perspective" that will be submitted by Denise van der Merwe (student number 22096647).

30/11/2016

Signature

Date

G.M. RUSSELL (BA)

Mem No: 9005051411

ANNEXTURE D - PERMISSIONS FOR FINAL COPY BINDING

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Higher Degrees Administration

AMENDMENTS AND PERMISSION TO BIND FINAL COPIES

(FOR SIGNING BY THE SUPERVISOR/PROMOTER)

Candidate: D van der Merwe Student number: 22096647

Qualification: Master of Development and Management

In accordance with the Statute of North-West University the undersigned declares the following with regards to the above-mentioned candidate:

1) The following title for the publication of the final copies of the candidate's thesis/dissertation/mini-dissertation corresponds exactly with the approved and registered title:

   Disaster Risk due to tracking in the fragile ecosystems of the Nama Karoo: A Disaster Risk Management Perspective

2) Amendments as indicated in the examiner's reports have been made to the satisfaction of the supervisor/promoter.
3) The final copies (electronic and hard copy) are in order and meet the specifications as set out by the NWU and the Ferdinand Postma Library.
4) The final copies are ready for binding.

A written report from the student that indicates where (pages) and which corrections were made to the final submission copy should be attached to this declaration.

Signature of Supervisor/Promotor: Date: 30/03/2017

The Research Director /Representative confirms that satisfactory proof has been provided of changes/ corrections made as indicated in the examiner's reports.

Signature of Research Director/Representative:

Date: 4/4/2017

Date stamp: