

**A comparative analysis of the vulnerability of  
informal and formal households to disaster risks:  
The case of Bekkersdal**

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Thesis accepted in fulfilment of the requirements for the degree  
*Doctor of Philosophy in Development and Management* at the  
North-West University

Promoter: Prof ES van Eeden

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Graduation: June 2021

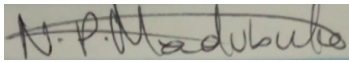
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## DECLARATION

I, Nomonde Patricia Madubula, hereby declare that the thesis: 'A comparative analysis of the vulnerability of informal and formal households to disaster risks: The case of Bekkersdal,' is my own work, all the sources used have been acknowledged through referencing and that this thesis has not been previously submitted by me or any other person for degree purposes at this or any other university.

Nomonde Patricia Madubula

31 March 2021



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Signature

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Date

## **ACKNOWLEDGEMENTS**

To the Almighty God! The creator of all things, I give thanks for giving me this opportunity, strength, wisdom and encouragement; God of our forefathers; Madubula, Nala, Ndokose, Gcalu, Nomaphelana, Zulu, Dlangamandla!

My deepest appreciation goes out to my supervisor, Prof. Elize van Eeden from the School of Social Science at the Vanderbijlpark Campus of the North-West University, for showing me the light through mentoring, guidance and support throughout the duration of my research. You remained consistent. Conducting this research was not an easy task as challenges and opportunities presented themselves but your patience with me and resilience prevailed.

I would also like to express my gratitude to my co-supervisor, Prof. Dewald van Niekerk from the African Centre for Disaster Studies at the Potchefstroom Campus, North-West University, as he is the one who encouraged me to pursue a thesis in disaster risk studies. I believe he saw the potential, dedication and keen interest I have in the field, and believed that I could do it; I thank you. I will forever be grateful for your constant positivity, words of advice and the guidance you gave me.

To the fieldworkers of the Bekkersdal community where this case study was conducted, I am in awe of your resilience and enduring hope despite the socio-economic and environmental circumstances you are faced with. You remained steadfast and committed to the pursuit of our shared vision and agenda, hence the survey results and analysis presented in this thesis. You generously shared your wisdom and advice. For this, I am deeply thankful and will forever remember your community, complete with its challenges and opportunities, as it holds a special place in my heart. More so to you, Mr. Lucas Thulare from the Federation for a Sustainable Environment, for serving with distinction as the research project contact person in the Bekkersdal community.

The financial support I received for my studies from the North-West University is deeply appreciated. I believe I would not have been able to finalise my academic studies without the support from the university.

I wish to express my sincere appreciation to my family, friends and colleagues for their support throughout my academic studies. They remained steadfast, giving emotional support, words of encouragement, wisdom and sharing their pride in my academic pursuits. I am especially grateful to my mom who did not know why I was studying again, yet she firmly believed I would succeed; to my uncles and aunts for their continued and undying love and support; to my partner and mentor, who without fail, planted the concept that I pursue these studies, and in good times and bad times, continued to push and support me so as to excel in my studies until the end, I will forever be grateful for your efforts; to my child Kumila Kuhle, who always said, *“mom, you study very hard and I want to be like you,”* much love to you.

Last, but not least, to Dr Tigere Chagutah from the Centre for Community and Social Development in Southern Africa, who professionally edited my work with precision, know-how and with diligence, much appreciation for representing my work so well.

## **ABSTRACT**

The study provided a comparative analysis of the vulnerabilities of households in both formal and informal settlements to disaster risks, including mining risks. Therefore, the study adopted a mixed qualitative and quantitative research methodology; with the case study approach used to evaluate the vulnerability of formal and informal households in Bekkersdal to disaster risks in an environmentally and economically vulnerable mining community, so as to be able to appropriately address key research problem and research questions. A case study approach was used to explain household vulnerability using mixed method, quantitative and qualitative, analysis. In the quantitative approach, descriptive analysis was used to determine variables that have a bearing on household vulnerability. The quantitative approach used estimation of the vulnerability index to determine household vulnerability among the formal and informally settled residents of Bekkersdal. Regression analysis was used to estimate the key determinants and drivers of vulnerability. Qualitative enquiry, comprising the administration of a survey questionnaire to disaster practitioners and officials responsible for managing disaster risks in the Bekkersdal community under the Rand West City local municipality, enabled a situational analysis of the community.

Overall, the results of the study indicate that livelihood variables matter and should be taken into account when measuring vulnerability of households to disaster risks. The study showed that households become exposed and vulnerable to disaster risks based on their geographical location and the lack of access to economic, physical, social and environmental resources exacerbate exposure and vulnerability. The community in the Bekkersdal area is surrounded by mining activities. The study showed that the negative outcomes of mining, such as acid mine drainage, sinkholes, dolomites, water and land pollution, and mining related ailments, amplify the vulnerability of the Bekkersdal community. The rapid increase in the number of households in informal settlements has had its own challenges, with poverty, unemployment and squalor becoming endemic in these areas. The study area sits on dolomitic land due to mining related environmental degradation and is therefore unsafe for building. As a result, it lacks critical infrastructure, which in turn, has led to increasing pressure on delivery of basic services. The negative mining activities in the area are therefore partly responsible for the limited

access to services for many households who are not connected to basic amenities such as electricity, water, sanitation, and sewerage systems in Bekkersdal. Thus, limited service delivery is a major secondary risk, which is driven by other primary risks such as the negative impacts from past and ongoing mining activities and their environmental impact in the mining community. The study revealed that households in Bekkersdal are vulnerable to various disaster related health risks that include cholera, skin rash and respiratory diseases resulting from exposure to mine effluent pollution in the area. Comparison between households in formal and informal settlements revealed that, whereas in urban townships negative environmental impacts of mining activities are damaging to wellbeing, the situation is far worse for households in informal areas as a result of their socioeconomic conditions. This is especially so for those living adjacent to mining activities and for migrants. The findings showed that some mining related disasters and disaster risks are caused by irresponsible gatekeeping in governing sectors. Such practices result in non-compliance by mining companies to relevant safety and care measures.

The study recommends that environmental impact assessment should be conducted throughout the life cycle of mining sites and mining activities should be interlinked so as to minimise their negative environmental impacts. Appropriate measures must be put in place to address and minimise the negative effects of mining activities in communities. Such measures would include protection of natural resources, sustainable mining practices which minimises negative impacts, and the rehabilitation of mine tailings. Further, effective disaster risk reduction mechanisms should be adopted. Such mechanisms should include households' own local conceptions in order to build trust between communities, decision makers and disaster practitioners and ensure robust practical measures for disaster risk reduction. Policymakers and disaster practitioners need to take into account socioeconomic and environmental factors in policymaking and implementation. These factors play a major role in determining vulnerability of households and in informing measures designed to improve their socioeconomic and environmental circumstances. The study recommends that appropriate measures should be in place to address occupation or building in informal areas, and to prevent informal or illegal construction, construction along riverbanks, and construction on storm water collection systems. Increased education and awareness are needed, including

discouraging households from settling on areas that are prone to disaster risks. The study recommends collection of data on disaster risks through mapping of vulnerabilities, so as to design effective response strategies. Further, it is envisaged that the study will add to the body knowledge and literature through revising some old techniques that have been used in disaster risk measures more so, on disaster risks surrounding mining communities.

**Keywords:** Disasters, Disaster Risk, Risk, Vulnerability, Household Vulnerability, Informal and Formal Households, Socioeconomic and Environmental Factors, Mining, Mining Activities, Bekkersdal.

## ACRONYMS

|          |                                                        |
|----------|--------------------------------------------------------|
| COGTA    | Cooperative Governance and Traditional Affairs         |
| CRED     | Centre for Research on the Epidemiology of Disasters   |
| CSIR     | Council for Scientific and Industrial Research Council |
| CVI      | Climate Vulnerability Index                            |
| DEA      | Data Envelope Analysis                                 |
| DRM      | Disaster Risk Management                               |
| FSE      | Federation for a Sustainable Environment               |
| GAR      | Global Assessment Report                               |
| HVI      | Household Vulnerability Index                          |
| IDP      | Integrated Development Plan                            |
| IMD      | Integrated Multidisciplinary                           |
| NDMF     | National Disaster Management Framework                 |
| RWC      | Rand West City Municipality                            |
| SADC     | Southern African Development Community                 |
| Stats SA | Statistics South Africa                                |
| SVI      | Social Vulnerability Index                             |
| UNISDR   | United Nations Office for Disaster Risk Reduction      |
| VI       | Vulnerability Index                                    |
| WFS      | Wonderfonteinspruit                                    |
| WHO      | World Health Organisation                              |
| WLM      | Westonaria Local Municipality                          |
| WRDM     | West Rand District Municipality                        |



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# CHAPTER 1

## OVERVIEW OF THE STUDY



The global community is facing a challenge of unprecedented proportions; climate change. Climate change poses significant challenges and many risks to global economies and community livelihoods. However, it is important to note that disaster risks are a result of many other factors besides climate change. Among the plethora of other drivers of disaster risks are inappropriate land use patterns, rapid urbanisation, poor storm water management systems and frequent droughts which are occurring in parallel with global environmental changes (Tsung-Huang & Wen-Cheng, 2020, Peduzzi, 2019, FAO, 2018).

South Africa has had a fair share of disaster events from beginning of the 20<sup>th</sup> century (COGTA,2005). In the past decade alone, the country has experienced some of the most devastating disaster events on record. Notable disaster events in the 21<sup>st</sup> century include the 2011 flooding in which more than 120 people were killed and some 20 000 people were left in need of assistance; the 2016 drought, considered the worst in a century; the 2017 fire hazards in the Western Cape that destroyed about 600 homes, and cost the country over 4 billion Rand (City Press, 2017); and the floods in the KwaZulu Natal province in 2017 which killed eight people, displaced 500 others and damaged dozens of buildings (FloodList,2017).

The frequency of such disasters has heightened the vulnerability and put to test the resilience of many communities in South Africa. Governments all over the world are intervening to improve the resilience of communities. However, in many instances these interventions fail to recognise the differential impacts of disasters on people's livelihoods as well as the differences in vulnerability between different households (Thomas *et al.*, 2019). Different communities in South Africa have been exposed to disaster events, albeit quite differently (Chersich & Wright, 2019, WRDM, 2017/18, WLM, 2011/12).

The impact of disasters depends on a number of factors, that include different socioeconomic conditions, and political, cultural and institutional factors (Adebimpe, 2011, Gallegos, 2011, DeBustillos *et al.*, 2002, Van Huyssteen *et al.*, 2002, Cannon, 2000, Mitchell, 1999,). Thus, identification of households that are vulnerable and drivers of vulnerability has become a key input for targeting interventions, and formulating, monitoring and evaluating adaptation and mitigation policies. Responding to disaster risks and ensuring that there are appropriate and targeted interventions, requires a firm understanding of the communities that are vulnerable to disasters and the factors that contribute to their vulnerability (Adebimpe, 2011, Gallegos, 2011, Cannon, 2000). In other words, a localised assessment of society's vulnerability is key to the crafting and implementation of policies and strategies to deal with vulnerability. Without a good grasp of the extent of a community's vulnerability and the factors contributing to such vulnerability, programmes and policies that are meant to mitigate the impact of disasters become inherently ineffective.

Literature that evaluates disaster vulnerability of households and communities is limited, both locally and internationally. Some of the few studies in this regard include Culwick (2019), Munyai *et al.*, (2019), Sawada (2012), Kurosaki *et al.*, (2011), Deressa *et al.*, (2009), UNISDR (2009), and Eriksen and Silva (2009). Considering the importance of comparative analysis of vulnerability in the design of disaster risk policies, it is surprising that comparative studies on the vulnerabilities of communities and households are few, especially those that compare the vulnerability of households in formal and informal settlements (alternatively referred to as formal and informal households elsewhere in the text)<sup>1</sup>. Among the few that compare the vulnerability of households in formal and informal settlements to disaster risks are Parker (1994), Dynes (1975) Miles (2012). These studies sought to understand the underlying causes of disaster vulnerabilities of households in different settlement patterns and to devise appropriate and well-targeted coping mechanisms. Findings from these studies suggest that vulnerability to disaster risks differs from community to community, and coping mechanisms are similarly diverse. These studies further note that the most vulnerable segments of society are

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<sup>1</sup> This thesis identifies and deals with matters concerning households in formally settled communities and households in informally settled communities at several places in the text. For brevity, and without prejudice, these households will, where appropriate, be referred to as formal households and informal households, respectively.

found among the poor, women and children, among residents of squatter settlements and among those settled in inappropriate and dangerous land zones. Other factors contributing to higher vulnerability include population density, inappropriate land use, and lack of preparedness on the part of disaster practitioners (Meheub *et al.*, 2019, Adebimpe, 2012, Dorbenstein, 2012, Miles, 2012, De Bustillos *et al.*, 2002, Parker, 1994).

In the South African context, comparative studies on the vulnerability of households in formal and informal settlements are also limited. Of the studies that exist, most looked at either informal or formal settlements in isolation. These studies include Melore and Nel (2020), Van Huyssteen *et al.*, (2012), Mathema (2011), Murray (2009), Aurecon (2008), and Napier and Rubicon (2002). The studies primarily focused on the impact of disasters in informal settlements in South Africa, while Murray (2009) examined the impact of disasters in the metropolitan area of Johannesburg. Aurecon (2008) assessed the vulnerability of several informal communities in the Western Cape. On the other hand, Napier and Rubicon (2002) analysed the vulnerability of informal settlements in the Western and Eastern Cape provinces. Melore and Nel (2020) focused on QwaQwa in the Free State province, while Van Huyssteen *et al.*, (2012) evaluated the vulnerability of informal settlements in South Africa, in general.

All these studies on South Africa generally emphasise and confirm the severe vulnerability of informal communities to disaster risks. For example, according to their calculated risk index, Melore and Nel (2020:7) note that informal communities in QwaQwa “have a low resilience because of the low levels of capitals available”. According to Williams *et al.*, (2018), the flooding that occurred in the Quarry Road West informal settlement in Durban in the KwaZulu Natal province was in the main due to the location of the settlement in a hazard area, in this case, on a floodplain. This location resulted in households with limited human, social, environmental and economic capitals being exposed to disaster risk, and as such, households in the area were unable to cushion themselves from the disaster risks and subsequent impacts.

Although most of the local studies inferred that the informal settlements are more likely to be vulnerable than households located in formal areas, generally, there is limited systematic, rigorous and comprehensive comparative analysis of vulnerabilities

between informal and formal households. This lack of information that compares the vulnerabilities of different communities, and the drivers of vulnerabilities, makes design of well-targeted policies very problematic (Meheub *et al.*, 2019). Considering the importance of assessing and comparing the vulnerability of different communities and the drivers of vulnerability, this study undertook a systematic and comprehensive comparative analysis of the vulnerability of informal and formal communities, using Bekkersdal town, a unique community surrounded by mining activities, as a case study.

## **1.2 BACKGROUND ORIENTATION**

The study entails a comparative analysis of the vulnerability of informal and formal households to disaster risks in mining areas. The investigation aimed at comparing how exposed informal and formal households are to vulnerabilities. The study employed a case study approach, focusing on the Bekkersdal informal and formal area within the present-day Rand West City Municipality (RWC), formerly called the Westonaria Local Municipality (WLM).

After the 2016 local government elections, Randfontein and WLM were merged to form RWC. The RWC falls under the West Rand District Municipality (WRDM) in the Gauteng Province of South Africa. Gauteng is the most densely populated province in South Africa, as it is home to 23% of South Africa's 58.8 million inhabitants (STATS SA, 2019). Bekkersdal comprises  $\pm 3,300$  formal households and  $\pm 13,000$  informal households (Lieverink *et al.*, 2017, Municipal IQ, 2013). According to figures from the 2011 Stats SA census, 42% of the Bekkersdal population is unemployed and 61% of households in the area receive an income of less than R19,600 per annum. Currently, the RWC has an estimated population of 265 538 people, and over 80% of this population reside in the Bekkersdal formal and informal areas (WRDM, 2019).

The Gauteng Province consists of three metropolitan municipalities; the City of Johannesburg, the City of Tshwane and the City of Ekurhuleni. The province also hosts two district municipalities; Sedibeng and West Rand (see Figure 1). The RWC, where case study was focused, is located in the West Rand District Municipality (see Figure 2 below). In 2017, the WRDM had a population of 838 594 people (WRDM, 2019, Global Insight 2017,). The constituent municipalities of WRDM had the following populations: Mogale - 382 613, RWC - 265 538 and Merafong - 192 762 (Ibid). Thus, the population

increase in these urban districts implies pressure exerted on the socioeconomic and environmental factors, such as the supply of basics and accommodation, among others. Increased pressure on these factors intensifies the vulnerability of households to various forms of disaster risks. Among these risks are the use of illegal electricity connections, use of catchment and underground water for household activities, and the building of informal settlements in unsafe places such as along floodplains and in dolomitic areas.

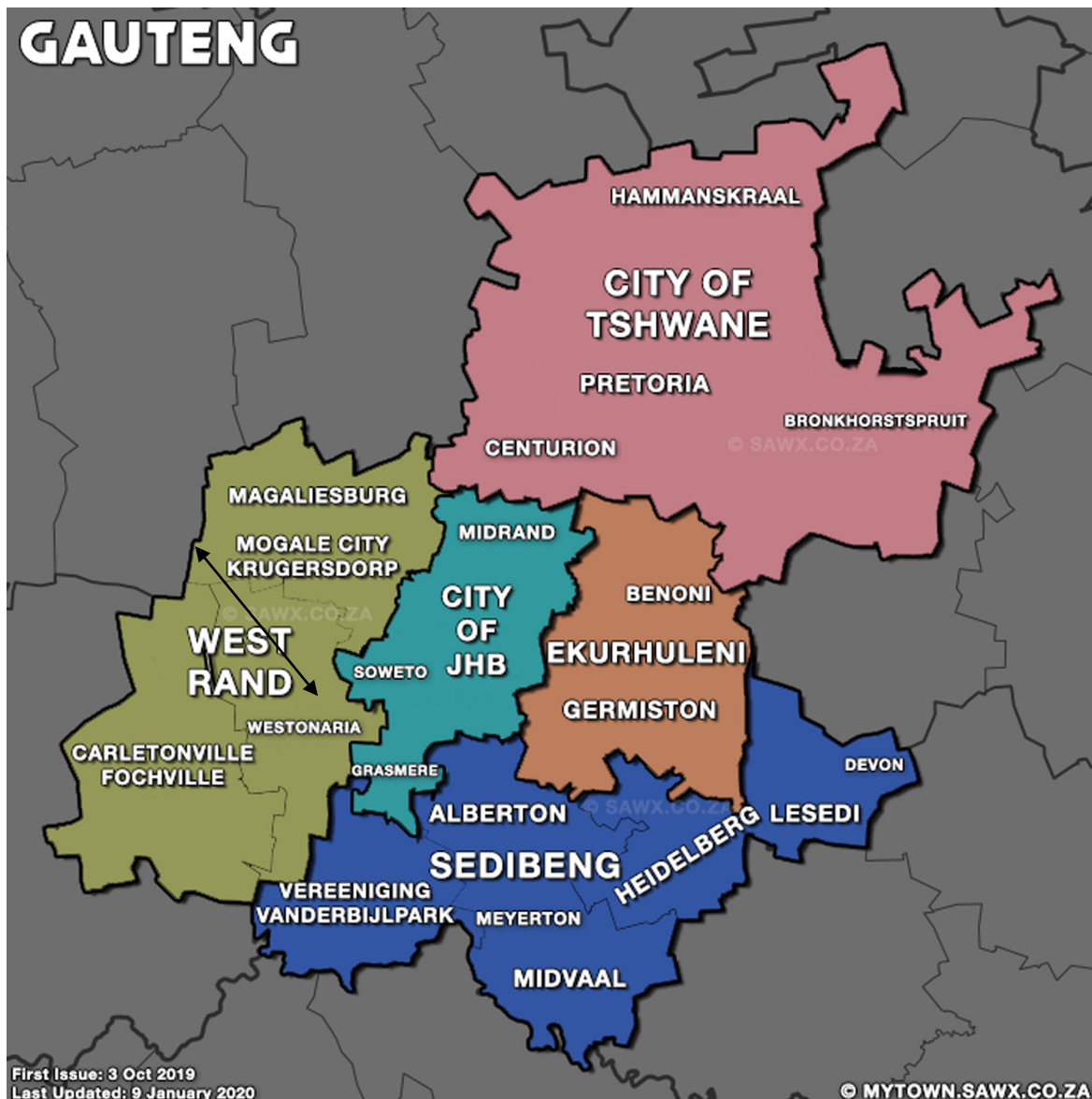


**Figure 1 Map of Gauteng Municipalities and Bekkersdal Town**

Source: SAWX (Accessed 24 July 2020)



**Figure 2 Map of WRDM Municipality**

Source: [www.municipalities.co.za](http://www.municipalities.co.za) (Accessed 5 November 2020)

Bekkersdal was founded in 1945, mainly to serve the developing mining sector in the Rand West City local municipality. The town gradually grew due to the influx of migrant labour from other provinces of South Africa as well as from the Southern African Development Community (SADC). In 2009, the population of Bekkersdal was estimated at 89 400, comprising 9 000 people living in formal settlements, 50 400 in informal settlements, and 30 000 residing in backyard shacks (Van Eeden, 2011, WLM, 2008/09). Westonaria, in particular, had 111 767 inhabitants, of which, 40 142 were said to be living in a formal household, with 62 911 living under informal circumstances (Stats SA, 2011). Currently, the RWC has an estimated population of 265 538 people, of whom 80% reside in the Bekkersdal formal and informal areas (WRDM, 2019). The reasons why there is such a large population residing in informal areas adjacent to the formal Bekkersdal settlements are numerous and complex. The rapid development of

the area due to mining activities has, over the years, attracted migrant labour from other regions of the country and from Southern Africa, especially from the SADC region. The surge in population in the face of limited available land has contributed to the mushrooming of informal settlements and an increase in the number of the unemployed. The situation has been further worsened by the downscaling of mining activities in recent years, with some mines even facing closure (CSIR, 2019, Steyn, 2019, WRDM 2019, Winde & Stoch, 2010).

Mining activities cause pollution, ecological degradation and widespread impacts on human health (Van Eeden, 2009). Karombo (2016), argues that due to its mining activities over decades, South Africa has the highest number of dangerous tailings dams which poses a risk as the dams could collapse. Mine tailings pose environmental risks not only in South Africa, but worldwide. To illustrate this point, a mine tailings dam collapsed in Brazil in 2019, contaminating the environment and killing people in the surrounding areas (Karonbo, 2016). Negative impacts due to mining activities have been recorded in Wonderfontein spruit (WFS) where the Westonaria town of Bekkersdal is located in the Gauteng province (Winde & Stoch, 2010). These included environmental degradation due to mine dewatering which forms dolomites and sinkholes, pollution, dust and contaminated water. Similarly, a report by the Gauteng City Region (2018) indicated that while gold mining activities boosted the economy, they have also contributed significantly to negative impacts on the environment, citing mining waste such as tailings, slime dams, open excavations and quarries. Liefferink and Van Eeden (2010), describe the effects of mining activities arising from acid mine drainage in the West Rand goldfields as the worst environmental injustice. According to (Davie, 2011:1) acid mine drainage refers to the “water that drains over the surface of acid-bearing rock which has been exposed through mining, becoming toxic as it rises to the surface of disused mines and making contact with air”. The area is surrounded by sinkholes, water pollution and dust fallouts, and its residents suffer from deteriorating health, in addition to high levels of poverty and unemployment.

Though the formal area of Bekkersdal had been serviced by the local authority after 1945, the country's racial policy and the sudden boom in urban development in the area resulted in inconsistent attention to the infrastructural urgencies in Bekkersdal. In addition, informal settlements were not officially recognised as they were deemed to

have been established on illegal land. Thus, they were not considered the property of- or as falling under the jurisdiction of the local/care-taking authority (Heinrich Boell Foundation, 2018, Buffalo City, 2010). Consequently, for several decades, the informal section and, to some extent, the formal section of Bekkersdal were characterised by a lack of basic services. This gave rise to social unrest after the Influx Control Act was abandoned in 1986. Subsequently, there arrived on the scene, political organisations that gave support to areas with limited structural access. This fomented political rivalry, culminating in brutal and violent practices (Van Eeden, 2014). Amidst all this, dynamic pressures, together with the intensive disastrous environmental exploitation at several gold mines (Van Eeden, 2006), exacerbated the vulnerability levels of households in the area. Moreover, the environmental effects were further worsened by the abandonment or closure of some mines.

### **1.3 PROBLEM STATEMENT**

As noted above (Section 1.1), South Africa has been affected by disasters of different types and proportions, both manmade and those caused by natural hazards. According to Mulugeta *et al.*, (2007), South Africa is prone to droughts, urban and rural fires, floods and dam failures, earthquakes and sinkholes, epidemics, storms, and spillages of hazardous waste and materials. Van Niekerk *et al.*, (2018), note that between 1980 and 2016, there were 89 declared natural disaster events in South Africa, causing 2 022 deaths and affecting more than 21 million people. The mining sector has experienced a fair share of disaster events. For example, sinkhole related disasters have regularly occurred in the West Rand part of Westonaria (Ngcobo, 2006). The dam wall, at the Lancaster dam in Krugersdorp, the West Rand, in the WRDM municipality, broke down spilling slime and toxic water which contaminated the WFS catchment area affecting livelihoods as the water is also used for drinking, farming and swimming activities in the area (Steyn, 2015). As such, the circumstances in Bekkersdal can be categorised as 'unique,' as they come over and above the day-to-day urban township challenges described above. Table 1 lists the major mining disasters recorded in South Africa over the past 60 years. These disaster events were mainly due to collapses, explosions and industrial strike action:



**Table 1 Major mining disasters in South Africa over the past 60 years**

| <b>Total Deaths</b> | <b>Date</b> | <b>Where</b>                                        | <b>Causes of Disaster</b>                                                                           |
|---------------------|-------------|-----------------------------------------------------|-----------------------------------------------------------------------------------------------------|
| 435                 | 21 Jan 1960 | Coalbrook North colliery near Sasolburg, Free State | Collapse of an underground mine area                                                                |
| 177                 | 16 Sep 1986 | Kinross mine in Evander, Mpumalanga                 | Miners were choked to death by toxic fumes from the combination of burning plastic and polyurethane |
| 53                  | 13 May 1993 | Middelbult colliery near Secunda, Mpumalanga        | Major coal-dust explosion                                                                           |
| 104                 | 10 May 1995 | Vaal Reef                                           | Underground locomotive carriage fell down a lift shaft                                              |
| 34                  | 10 Aug 2012 | Marikana Platinum mine, North-West province         | Miners shot dead during protest over wages                                                          |

Source: Phala (2016)

Coetzee and van Niekerk (2013:351) argue that due to South Africa's past legacy, the urban landscape is skewed, with the majority of the population living in susceptible areas, such as informal settlements, overcrowded places, and floodplains, and around mining sites where there are dolomites and sinkholes. The majority are, thus, susceptible to various types of disasters. A study by the National Department of Public Works identified 47 municipalities in the Gauteng province as being located or partially located in dolomitic areas (Department of Public Works, 2003). These areas are in municipalities such as the RWC municipality where Bekkersdal is located.

The Government of South Africa has initiated many different programmes and strategies to ameliorate the impact of disasters on communities and households (COGTA, 2005, WLM, 2011). However, the data on which most interventions are based

lacks localised information whereas, in many instances, disasters are localised. Municipalities and disaster practitioners do not know which households are vulnerable to disasters and why this is so. They lack knowledge on the key drivers of household vulnerability and the measures that need to be in place to address vulnerability and impact of disasters. More so, questions abound on whether South Africa has the ability to manage disaster risks in formal and informal settlements in dolomite depleted and distorted regions arising from mining practices. These conditions normally impact on the potential for urban growth, reduce environmental health and limit job opportunities in the rain season (Marais and Nel, 2016, Ackerman *et al.*, 2018). Questions and concerns such as these are critical, as they assist in the design of appropriate coping measures for different communities (Miles, 2012, Mitchell, 1999). Answers to these questions are also key for the effective targeting of interventions.

There is abundant literature with evidence that different social groupings are affected by disaster risks differently (Meheub *et al.*, 2019, Abunyewah *et al.*, 2018, Thomas *et al.*, 2018, Le Roux *et al.*, 2017, Van Huyssteen *et al.*, 2013, Parker, 1994). These authors contend that any interventions meant to ameliorate the consequences of disasters should always be based on, or supported by, concrete evidence on the vulnerabilities of households. Parker (1994), for example argues that disaster practitioners fail to target their interventions mainly because they are unable to distinguish the vulnerabilities of different social groupings. Thomas *et al.*, (2018:1) observe that vulnerability is a “multidimensional process affected by social, political, and economic forces interacting from local to international scales”. It is critical that interventions should be supported by robust comparative analysis of community and household vulnerabilities in order to ensure effective targeting (Ncube *et al.*, 2016, Van Huyssteen *et al.*, 2013). Thus, providing an array of evidence or undertaking comparative research can serve as the basis for crafting well-targeted instruments and intervention programmes. As noted by Van Bavel and Curtis (2016), Sasaki (2014), Parker (1994) and Dynes (1975), comparative studies originating from the multidisciplinary research tradition, including from risk and disaster research, are a valuable tool for understanding how communities from different backgrounds, and those with different means, cope and adapt to different socioeconomic circumstances.

Van Bavel and Curtis (2016), highlight the value of comparative research in studying disaster risks, wherein comparative research is crucial for understanding critical societal characteristics that influence effective response to disasters. They note that:

*... [the] issue of social contextualization is also vital to understand and explain the degree of resilience of different groups or categories of people within a community - in relation to hazards and shocks. It is only through this comparative route that we can understand how disasters impact on social, environmental and economic inequality over the short and long term, by placing the trends in direct relation to those societies fortunate enough to escape the same severe shocks.*  
(Van Bavel & Curtis, 2016:154).

The authors argue that scholars and disaster practitioners should be looking to move away from comparing disasters *per se* towards comparing a number of different societies' experiences of one shock. Comparative research also helps to identify coping strategies and to decide what changes or policies must be implemented. There are many examples of such studies, including Bollig (2010) who compared the coping strategies of Kenyan pastoralists. There are several other advantages of conducting comparative research – especially on household vulnerability. Comparative assessment offers policymakers a chance to avoid repeating past mistakes and it enables them to save time by targeting resources effectively to deserving groups (Fernandez *et al.*, 2006). As Peacock (1997), notes comparative research enables better identification of differences and similarities between different groups and clearer understanding of the various consequences of interventions, which enables more efficient allocation of resources. The argument is also supported by others (Smart, 2012, Gallegos, 2011, Jahangiri *et al.*, 2011, Fernandez *et al.*, 2006).

However, there is limited literature that rigorously and comprehensively compares formal and informal settlement community vulnerabilities in South Africa. Attempts at closely evaluating formal and informal household vulnerability differentials can be found in Jordaan *et al.*, (2019), Williams (2019), Marais *et al.*, (2018), French *et al.*, (2017) Le Roux *et al.*, (2017) Ncube *et al.*, (2016), Le Roux *et al.*, (2015), Van Huyssteen (2013). For example, Le Roux *et al.*, (2017) have provided evidence showing that pockets of severe social vulnerability within the metropolitan municipalities are strongly correlated

with where informal settlements are located. Williams *et al.*, (2019) explored the vulnerability of informal settlements to climate change induced floods using the lens of socioecological systems analysis. This study observed that structural inequality is a major driver of risk in informal settlements, and more so, when it comes to disasters recorded in informal communities compared to formally settled areas surrounding mining activities.

Marais *et al.*, (2018) assessed the poor living conditions in the communities of Postmansburg in the Northern Cape. The study found that mining activities in the Postmansburg area have an impact on the nature of housing within informal settlements due to their uptake of contract workers. Typically, the informal households/settlements have lower or limited access to basic services such as water, sanitation and electricity, and lower resources, education or skills compared to formal households in the area (Marais *et al.*, 2018). Jordaan *et al.*, (2019) conducted a case study of the formal and informal settlements within the WFS catchment area impacted by operational and abandoned gold mines in the West Rand. The study found that composition of bacterial communities differed significantly between less (downstream) and more (upstream) polluted sites. The study showed that anthropogenic disorder, such as mining, urban and rural settlements, sewerage works and agriculture, negatively affect freshwater systems, water quality and ecosystem health. Also, the lower WFS river had the highest mercury contamination originating from mine waste from gold mines, domestic wastewater treatment plants, urban and informal settlements, as well as agricultural runoff.

French *et al.*, (2017) in Bolivia, assessed water availability and quality related hazards and vulnerability due to mining activities in the area. The study focused on two communities: communities without mining activities versus communities surrounded by mining activities. It was found that communities surrounded or closer to mines were vulnerable and exposed due to the environmental risks such as water pollution, acid mine drainage and tailings. Such communities also suffered more health related issues over and above the socioeconomic ills they faced in their everyday lives.

Notwithstanding the demonstrated utility of a detailed understanding of localised household vulnerabilities, research on household vulnerability remains limited as stated

above. Key reasons for the gap include, among others, limited availability of research tools for measuring vulnerability, and data limitations. In addition, despite the value that information which isolates the key drivers of vulnerability brings to policy and interventions designed to mitigate the impact of disasters, such information is quite limited. Together, these challenges result in limited knowledge among disaster practitioners on how to target households impacted and/or affected by disasters. In addition, capacity to respond to targeted households is limited by the absence of strategies to ensure necessary and effective interventions.

This study sought to fill this gap by carrying out a comparative analysis of the vulnerability of informal and formal households to disaster risks, in especially those in gold mining areas, focusing on Bekkersdal as the case study site.

The area of Bekkersdal provides for a compelling case study of localised community vulnerability for several reasons. First, the community of Bekkersdal is unique in the sense that it is largely located in a dolomite area with many sinkholes, and acid mine drainage decanting and spillages. Second, the community faces many other challenges, among them, high levels of water pollution due to the environmentally unfriendly mining activities in the area, inappropriate land use planning, frequent flooding due to inadequate storm water management systems, frequent droughts, acute erosion due to unstable soil structures and underlying geological factors, rapid urbanisation, and a high frequency of uncontrolled veld fires (Lieberink, 2019, WRDM, 2019, Ackerman *et al.*, 2018, Marais *et al.*, 2018, Koen *et al.*, 2017; WRDM, 2016, Utembe *et al.*, 2015, Van Eeden, 2014, Coetzee & van Niekerk, 2013, Van Huyssteen *et al.*, 2012; WLM, 2011/12, Winde & Stoch, 2010, Van Eeden, 2009). South Africa's settlements are complex as they are characterised by, among others, inequalities that are starkly evident of the legacy of apartheid. Thirdly, pressures brought about by climate change make localised studies of vulnerability very interesting, informative and relevant.

The Bekkersdal area has had many episodes of disasters, including sinkholes caving in, floods and fire hazards (Nealer, 2020, WRDM, 2019, WRDM, 2016/17, Olalde, 2016, WLM, 2011/12). For example, in 2016, the whole area surrounding Bekkersdal was declared a local state of disaster under the Disaster Management Act, due to numerous sinkholes destroying, among other things, water access and waste disposal

infrastructure, leaving thousands without access to basic services (Olalde, 2016). In 2018, children died in the Spook town informal settlements due to one of numerous fires recorded in the area (Eyewitness News, 2018). The impact of these disasters on the local communities were severe, especially on the residents of informal settlements (WRDM, 2016/17, 2011/12, WLM). Some of the reasons for the severity of disasters, include rapid urbanisation, improper planning, population density, and inappropriate building construction. Poor maintenance of infrastructure and poor training of officials on managing and addressing disasters were singled out as additional factors contributing to the severity of disaster events (WRDM, 2016/17, WLM, 2011/12,).

The environment management report of the WRDM (2013), states that the closure of some mines, slime dumps and the non-compliance with laws stipulating rehabilitation of mine tailings exacerbated the situation in the surrounding areas. Rand West has several tailings dams which are a major source of dust, whilst informal settlements pose threats to the environment as there is no control over the location of these settlements. These settlements often emerge in highly sensitive environments and consequently, informal settlements themselves pose significant threats to people's health and safety. Informal settlements are also prone to flooding as there are no reliable storm water infrastructure systems. Thus, the mining activities in the Bekkersdal area contributed to environmental degradation, contamination of water and associated health problems (Koen *et al.*, 2017, WRDM, 2013).

To address the problem stated, the study pursued a comparative, but localised, analysis of the vulnerability of informal and formal households to disaster risks at Bekkersdal in the RWC. The human distorted, exploited and degraded environment of Bekkersdal serves as an appropriate platform for the research.

## **1.4 RESEARCH QUESTIONS**

The primary research question in the study sought to identify the underlying drivers of vulnerability to disasters in communities surrounding mining activities and to determine whether forms of disaster vulnerability do indeed differ in and between informal and

formal households in the urban areas of Bekkersdal. The study addressed the following specific secondary questions:

- What do the theoretical and conceptual frameworks that underpin disasters, disaster risks, household vulnerability and comparability thereof to disasters entail, with specific reference to disasters in environmentally brittle mining areas?
- What models related to disasters, disaster risks, vulnerability and resilience of households in informal and formal areas currently exist as research guidance for identifying and comparing risks in mining areas?
- What is the historical evolution of disasters, disaster risks, and levels of vulnerability of informal and formal households in the Bekkersdal area?
- What are the vulnerability levels and drivers of vulnerability in both informal and formal households in the Bekkersdal township?
- What recommendations can be made regarding the management of disaster risks and vulnerability of the households in the post-mining risk area under study?

Having identified the research questions, key research objectives were defined to guide the research.

## **1.5 RESEARCH OBJECTIVES**

The purpose of this study was to determine vulnerability of households to disaster risks and, in addition, to compare the degree of vulnerability of informal and formal households, with a special focus on the Bekkersdal community in the RWC. The specific objectives identified were:

- To theoretically and conceptually evaluate the concepts of disasters, disaster risks and vulnerability with particular reference to disasters in environmentally brittle mining areas and focusing specifically on households in formal and informal settlements.

- To review current models on disasters, disaster risks, resilience and vulnerability levels of informal and formal households in mining areas and to establish, through qualitative fieldwork research, whether gaps exist.
- To examine the historical evolution of disasters, disaster risks and vulnerability of informal and formal households in the Bekkersdal area of RWC.
- To examine vulnerability levels and drivers of vulnerability of informal and formal households in the Bekkersdal area of RWC.
- To make recommendations regarding the management of disaster risks and vulnerability of the households in the post-mining risk area under study.

## 1.6 CENTRAL THEORETICAL STATEMENT

As alluded (Section 1.1 and 1.3) in this document, various studies have analysed vulnerability to disaster risks at household level, comparing levels of vulnerability between formal and informal households, where policies are expected to reflect such a distinction. This has been acknowledged by Van Huysteen *et al.*, (2012) Mathema (2011), Murray (2009), Aurecon (2008), the National Disaster Management Framework (NDMF) (2005), as well as by Napier and Rubin (2002). The authors argue that one of the challenges that hamper effective disaster risk management is the lack of adequate data and information on vulnerability studies based on assessments and relevant comparisons. When disasters do occur, affected municipalities often fail to render the support needed; simply because they do not know how and where to prioritise in respect to the households that are most vulnerable. This has been the case in Bekkersdal as acknowledged in the State of the Environment Report (2011/12) and by the WRDM (2016/17) which stated that, even though local disaster management practitioners responded to disaster-struck areas with some assistance, the capacity to respond appropriately and to target those communities effectively was sorely lacking as there normally are no proper strategies in place.

A comparative approach is even more important for understanding the vulnerability of formal and informal households settled in the disaster prone, environmentally brittle,



gold mining areas of Bekkersdal, where policies and interventions would be expected to be well differentiated.

## **1.7 METHODOLOGY**

This study adopted a multidisciplinary approach cutting through across many disciplines. It brings together environmental science, economics, sociology, and history, among others, and it fuses together econometric and climate change modelling. Therefore, the study adopted a mixed qualitative and quantitative research methodology; with the case study approach used to evaluate the vulnerability of formal and informal households in Bekkersdal to disaster risks in an environmentally and economically vulnerable mining community. Therefore, this study explored quantitative primary survey data and qualitative, secondary, data from focus group interviews, informal discussions, published literature, policy documents and legislative instruments. Schurink and Auricombe (2010) describe qualitative research as being interdisciplinary and transdisciplinary in nature as it cuts across social and physical sciences. They further stated that when one is faced “real life context,” it is critical to employ qualitative research through the case study approach for investigation. The history of the Bekkersdal community, comprising both informal and formal households, was studied in relation to its vulnerability to disaster risks, encompassing floods, veld fires, negative mining-related activities, and wellbeing related matters.

### **1.7.1 Literature Review**

The extensive literature reviewed in the present study is broadly divided into two: conceptual and theoretical literature on disaster risks and vulnerability, and empirical evidence on the same. The empirical literature starts by reviewing the historical evolution of the Bekkersdal community, followed by literature on vulnerability assessments and finally, literature which compares vulnerability levels and the drivers of vulnerability of informal and formal households.

The present study included a thorough review of literature covering international and national experiences, and primarily focused on issues of household vulnerability to disaster risks, comparative vulnerabilities to disaster risks between informal and formal settlements, the definitions and theories of disaster risks, disasters, resilience and

vulnerability. The study differentiated between formal and informal households, explored models of vulnerability to disaster risks, and surveyed the history of the Bekkersdal community. The study was primarily informed by the following literature survey:

Linnekamp *et al.*, (2011) used a household vulnerability model to assess rainfall and flooding patterns, and their link with inequalities in urban areas to investigate arguments that vulnerability to disasters was unevenly spread as a result of inequalities. In conducting their study, they selected wards as sites of investigation based on their level of vulnerability as inferred from income levels. Coping and adaptive measures of households drawn from the interviews were analysed. The study also assessed risk and disaster management in areas surrounded by mines.

Durrheim *et al.*, (2006) assessed disaster risk related to mines and caused by seismicity in gold mining areas in Klerksdorp and the Free State province. The findings of the study indicated that past as well as present mining do trigger seismic events and buildings in the surrounding areas were vulnerable to disaster risks, damage or structural collapse. The paper recommended that mining districts should incorporate risks of seismicity in disaster risk management activities and include appropriate training to members of emergency services.

The objectives of a PlaNet Finance (2010) study were to improve the evidence base for disaster risk management (DRM) and to propose effective disaster risk management practices for disaster practitioners and community members so as to enable both to address and reduce the causes of vulnerability. The study used both primary and secondary data. Surveys were conducted in the municipalities selected. The results indicated that people were vulnerable to disasters (typhoons, heavy rains, strong winds, floods and landslides) due to, among other things, the geographic location and topographic composition of the areas in which they resided, and the amount of income or sources of income received per household. Vulnerability was determined by age and sex of household members, and the nature of the house in which the subjects lived.

Ncube-Phiri *et al.*, (2014), Bhebhe (2013) assessed environmental risks associated with artisanal small-scale mining activities. Results of the studies indicated that artisanal small-scale mining does contribute negative environmental impacts in the form of deforestation, burning of bushes, soil erosion and water pollution from the use of

mercury and waste materials. Further, there are also environmental related health challenges associated with the death and burning of animals in veld fires, as well as respiratory and cardiovascular diseases.

Eisler (2003), argues that miners and households who reside nearby gold mining activities are exposed to health diseases and the situation is worse in South Africa, given that it is the largest producer of gold in the world. Thus, diseases such as TB, bronchitis, dengue fever, noise induced hearing loss and cancer are rife in the country.

The study uses the Vulnerability Index (VI) and Social Vulnerability Index (SVI) to measure vulnerability and employs the Data Envelope Analysis (DEA) and Household Vulnerability Index (HVI) models for analysis in the case of Bekkersdal. The approach by Wisner *et al.* (2003, 2004) for analysing evolution of vulnerability caused by root causes, dynamic pressures and unsafe conditions was adopted in this study in Bekkersdal. Disaster risk assessments by Peduzzi *et al.*, (2009), Xiaoyan and Xiaofei (2012), also informed the present study as well as the analysis of the relationships between the concepts of vulnerability, household vulnerability, disasters, and disaster risk.

The study borrowed from the work of other authors to inform its comparative approach. Parker (1994), compared the vulnerability of informal and formal settlements in Istanbul by differentiating between social groups. People living in poverty and experiencing physical and physiological factors were predominantly low-income earners and those who lacked ownership of land (Dorbenstein, 2012, De Bustillos *et al.*, 2002). Practical approaches for comparing vulnerability levels of households using the Climate Vulnerability Index (CVI) were explored. In comparisons of the effects of (gold) mining in communities residing adjacent to mining sites, studies by the World Resources Institute (2003), Pokorny *et al.*, (2019) indicate that households who suffer the most from mining activities are those in communities that are already in compromised situations. That is, those already socially and environmentally vulnerable due to high poverty levels, low levels of education, uneven wealth distribution, and residing in risk prone areas characterised by tailings and sink holes. Results of these studies indicate that negative gold mining effects and environmental risks are severe where households lack resources and education and have poor market access than their counterparts.

Households who have access to resources and favourable socioeconomic conditions are generally better off. Thus, locally contextualised existing vulnerability adds to the impacts of mining activities.

The study leant on and extended the work of Gallegos (2006), Fernandez, *et al.*, (2006), Peacock (1997), Parker (1994), Dynes (1975) on the crafting and use of well-targeted instruments and intervention mechanisms. Further, practical approaches of comparing vulnerabilities levels of households using CVI methods were explored. In comparing the effects of (gold) mining to communities residing nearby. Studies by World Resource Institute (2003), Pokorny *et al*, 2019 indicate that households who suffer the most from mining activities are those communities who are already in compromised situation. That is, social and environmental vulnerable in terms of high poverty levels, low levels of education, uneven wealth and distribution, prone areas (dam tailings and sink holes). Results of these studies indicate that negative gold mining effects environmental risks) are severe where households lack resources and education, poor market access than their counterparts (households who have access to these resources/ favourable socioeconomic conditions and thus local context vulnerability adds to the intensity caused by mining activities).

### **1.7.2 Research Design**

The history and evolution of the Bekkersdal community, both informal and formally settled, were examined in relation to vulnerability levels and disasters. Several instruments were employed to gather information from the respondents. Questionnaires were used mainly for quantitative data gathering. To gather qualitative data, interviews with key informants and focus group discussions were conducted, along with a review of the literature. The key informants for unstructured interviews were government officials and disaster practitioners.

The questionnaire was adapted from a baseline questionnaire as elaborated in section 5.3 (research methodology) of this thesis. It was used as the main information capturing instrument on the levels of household vulnerability of the local communities. The questionnaire was completed by a sample of residents of the Bekkersdal community, ward councillors, committee and community leaders. Households from both informal

and formally settled areas were targeted for the data collection. A team of trained enumerators administered the research instruments.

### **1.7.3 The Qualitative Analytical Method**

Analysis of the gathered data was qualitative. The qualitative approach is flexible and open-ended as it does not make provision for factors or variables; it is based on dynamic events and processes (Auriacombe & Mouton, 2007). Qualitative analysis simply describes the viewpoints of the interviewees. Non-quantitative information gathered from literature, focus group discussions and unstructured interviews with households (formal and informal) of Bekkersdal, municipal government officials and disaster management practitioners lent itself well to qualitative analysis. The number of respondents for the unstructured interviews were determined as the research progressed and interviews were conducted as informed by the ethical principles as outlined for the broader Bekkersdal project. These applicable ethical principles are detailed later in this chapter.

Several sources of secondary data were consulted, the sources consulted included but were not limited to the following: including the national disaster management framework; legislation and policy with regard to disaster risks; government database encompassing municipal information and records of disasters in the study area, vulnerability information and disaster risk interventions implemented; the disaster management database of the RWC; state of the environment reports; provincial disaster reports and frameworks; disaster practitioners' records; books, journals, reports and other relevant and available documentation.

The qualitative analysis focused on identifying emerging themes, patterns, relationships, trends and data categories. Qualitative analysis begins with data collection and continues until all the data as evidence have been collected, processed and interpreted (Auriacombe & Mouton, 2007, Harding & Whitehead, 2010). In this study, this involved transcribing, describing and interpreting information gained from discussions, field notes and interviews with participants in order to gain insights and understanding regarding their feelings, inferences, thinking, perspectives, perceptions and interpretation of particular situations.

#### **1.7.4 The Quantitative Analytical Method**

The quantitative part of the analysis was informed by the structured part of the questionnaire. The purpose of the quantitative element of the study was to quantify the disaster risk vulnerability levels of the formal and informal households in a brittle mining area. The first part of the analysis following data capturing was descriptive. The data generated from administration of the questionnaire was processed and organised, checked for accuracy and captured in excel software. SPSS and STATA software were used to analyse the data. The data was classified and coded. The first part of the analysis following data capturing was descriptive, with some information presented graphically.

This entails creating discrete variables from the questionnaire and then using these to describe the sample in terms of measures of distribution: means, standard deviations, frequencies and proportions. This information was presented by means of graphs and tables. The purpose of the descriptive measures was to present the situation at the time of the study and enable the researcher and reader to gain insights into context at the time of the investigation and interrelationships between key variables.

After defining the sample, household vulnerability was estimated. A composite index of vulnerability was computed following the household vulnerability index (HVI), a statistical measure for quantifying household vulnerability. The HVI was based on five capitals: (i) natural assets such as land, soil and water; (ii) physical assets such as livestock and equipment; (iii) financial assets such as savings, salaries, remittances or pensions; (iv) human capital assets such as farm labour, gender composition and dependents; and (v) social assets such as information, community support, extended families and formal or informal social welfare support, which when lacking, the household becomes vulnerable especially to environmental and economic disasters. Without any of these capitals, the household cannot withstand the effects of a disaster and as such they become vulnerable. This analysis is discussed in greater depth in Chapter Five which covers the methodological approach of the study.

Furthermore, correlation and regression analysis was used to quantify the influence of key variables such as financial, human, natural, physical and social capital on household vulnerability. In other words, regression analysis was adopted to isolate the

determinants and causes of vulnerability between informal and formal households (Matyas & Pelling, 2012, Van Huyssteen *et al.*, 2012, WRI, 2003, De Bustillos *et al.*, 2002, Cannon, 2002, DFID, 1999) – see Table 2 below. To ensure the validity and reliability of correlations and regressions, a barrage of tests was applied, including t-tests and Chi square tests. These tests are key to establishing the reliability of the results.

As mentioned earlier, the questionnaire method was used in this study to collect data on how disaster risks as identified in mining settings are related to vulnerability determinants such as the financial (savings and credit), human (skills, knowledge, health), natural (land, water), physical (infrastructure, technology and equipment) and social (networks, groups and institutions) capital dimensions of households.

**Table 2 Determinants and Components of Vulnerability**

| <b>Components of vulnerability</b> | <b>Variables involved</b>                | <b>Socioeconomic and Environmental Aspects</b>                                                               |
|------------------------------------|------------------------------------------|--------------------------------------------------------------------------------------------------------------|
| Financial Capital                  | Savings / Credit                         | Do households have access to savings or credit?                                                              |
| Human Capital                      | Skills, Knowledge, Health                | Households skills and education, know-how and health status                                                  |
| Natural Capital                    | Natural Resources, Land, Water           | Access to land, water<br>Do households have access to land to farm, to mine, access to water for livelihood? |
| Physical Capital                   | Infrastructure, Technology and Equipment | Do households have access to infrastructure, technology and relevant equipment?                              |
| Social capital                     | Networks, Groups and Institutions        | Household involvement in relevant groups and networks                                                        |

Compiled from Matyas and Pelling (2012), Van Huyssteen *et al.*, (2012), De Bustillos *et al.*, (2002), Cannon (2002), DFID (1999).

The questionnaire developed also included a mixture of both open and close-ended questions. This was to allow respondents room to provide more information (in the case of open-ended questions), and at the same time limit respondent choices regarding some questions (close-ended) to allow for comparisons. The envisaged sample size was 1 000 households (see section 1.7.5).

In line with international literature the structure of the questionnaire was as follows:

**Section 1:** household identification which encompassed household name/s, the ward area they reside in, their contact number, and household members' skills in languages;

**Section 2:** gathered personal information on the age of the household members, their employment and marital status, educational qualifications attained, their residential status, including the type of household structure, and health and disability status;

**Section 3:** focused on the vulnerability status of the household through ascertaining whether they have access to assets/capital in the form of physical, financial, natural, human, social and economic;

**Section 4:** assessed the environmental and economic pressures faced by households and the community in the Bekkersdal area;

**Section 5:** probed disaster events/ incidents experienced by the household in the gold mining specific area;

**Section 6:** explored the mitigation and adaptation measures that households used/have access to when faced by disaster events/incidents;

**Section 7:** ascertained which members are most affected by the array of impacts associated with the gold mining specific area in a vulnerable household.

### **1.7.5 Sampling**

A sample is defined as a subset of a population that has been observed so as to make inferences about the nature of the general population (Burger & Silima, 2006). In the main, a sampling method is chosen for its ability to enable generalisations. A multi-staged sampling procedure was used in the present study. The sample of 1 000



households was both purposively and randomly selected from formal and informal settlements of the Bekkersdal area. Bekkersdal, was selected in order to take advantage of and build on past research work conducted in the area.

The Bekkersdal integrative multidisciplinary (IMD) project baseline questionnaire (Koen, *et al.*, 2017, Liefferink, 2015, Ryke *et al.*, 2015) was used as a point of reference to craft the questionnaire used in this study. The questionnaire was purposively administered in the formal and informal household areas. The criteria for selecting which households to target between formal and informal households in the study area included their respective wards, their accessibility and proximity to the researcher. Households in each selected ward, both informal and formal, were randomly selected thereby offering an equal opportunity for all households to be selected. In addition to households, government officials were selected through purposive sampling. Purposive sampling was used to target officials as it was accepted that they have more insight on their wards, some managerial expertise, they are knowledgeable with regard to disasters and can contribute to relevant data on disasters in this mining region.

### **1.7.6 Data Collection**

Primary data<sup>2</sup> was collected from the sample of the Bekkersdal population, representing both types of households in informal and formal settlements. The sample size was 1000. The primary data that informed the major part of the analysis in study was from a survey of informal and formal households in the sample conducted in the years 2015 and 2016, in the Bekkersdal area. Focus group discussions served as another source of data, with information from focus group discussions used to gain insight into the formal and informal household members' perceptions and experiences on their vulnerability to disaster risks as encountered in the West Rand gold mining region of which Bekkersdal is part of. A questionnaire was designed. The following principles guided design of the questionnaire<sup>3</sup>:

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<sup>2</sup> Primary data refers to first-hand information collected by the researcher on a specific project and it can be in the form of a survey or interviews, just like the case of Bekkersdal in this context.

<sup>3</sup> Mr Lucas Thulare IMD contact person in the Bekkersdal community area (Employee of the FSE) Fieldworkers who reside in Bekkersdal in both the formal and informal setting; Researchers/ Students from North West University who work on various projects in the Bekkersdal through IMD projects.

- The questionnaire must be short, simple, clear and concrete. Language used must be clear and familiar.
- The questions should progress from easy to difficult.
- For objective information, open-ended questions are used.
- Questions should evoke reliable and valid answers.
- Response options should not overlap.
- Questions should have a logical sequence.
- Questions should avoid order bias by not giving away an answer before asking the question.

Data gathering also included secondary data. Data collected from secondary sources was informed by key issues arising from reviewed literature, and elicited a mixture of responses on the following:

- Socioeconomic indicators: age, sex, household size and income level, assets and savings, ethnicity and civil society;
- Environmental indicators: floods, fires, drought, mining-related risks and activities;
- Physical indicators: type of housing, access to water, sanitation, electricity, roads, transport facilities;
- Capacity indicators: early warning detections in place, availability of disaster mitigation measures in place, community awareness, programmes and projects implemented by government and other disaster practitioners, community measures in place (including answering the research questions under study). Whether the capacity indicators would be too complicated for the residents in Bekkersdal formal and informal households was to be determined as an observation after the completion of the study.

## **1.8 LIMITATIONS AND DELIMITATIONS OF THE STUDY**

The study mainly focused on the Bekkersdal area in the RWC in the Far West Rand and was intended to cover both informal and formal households. It compared vulnerability

levels to disaster risks in the area and coping mechanisms currently in place and used – implying that it employed a case study approach. However, the potential for sampling error and biases cannot be ruled out. That was mitigated by the use of random sampling so as to give equal chance of opportunity as well as the use of regression analysis which showed a significant positive result between the variables. Generalisation arising from the study was limited, as the sample was a representative and therefore did not cover the whole population. On the other hand, resource constraints did not allow for a larger, more representative sample, however, the sample size used was considered sufficiently representative.

On the delimitations of the study, it is important to note that the study was limited to Bekkersdal formal and informal settlements. The study covered vulnerability to mainly disasters involving floods, fires, several mining-related activities and drought. The focal point of the study was not the individual, but the household in both the formal and the informal settlements in the Bekkersdal area.

## **1.9 ETHICAL CONSIDERATIONS**

This research was undertaken in accordance with the strict research guidelines of the North-West University. Ethical clearance and permission were granted to the Community Engagement Integrative Multidisciplinary Project related to the Environmental Health and Wellbeing of Mining Communities NRF-funded project to conduct research in Bekkersdal (See Ethics no. FH-BE-2013-0014). The RWC approved the IMD research in the Bekkersdal area. These documents of approval are available on request. The ethics application also required that data in this research be protected by the NWU (the Promoter of the study) for a period of five years, thereby also protecting the anonymity of the participants.

## **1.10 SIGNIFICANCE OF THE STUDY**

In essence, the outcome of the research was threefold. Firstly, to inform the scientific community on research in mining risk areas in which economies and environments are facing serious long- and short-term risk factors. Secondly, to inform decision-makers about the risks mining communities face or can face against the background of a lack of disaster impact assessments. Lastly, but importantly, the study can further guide gold

mining companies, researchers and the local municipalities in understanding and responding effectively to the community voice on their experiences and status in relation to disaster risks.

In general, the results and recommendations of the study add to the body knowledge and literature by revisiting some old techniques that have been used in disaster and vulnerability management and coping measures. The study achieves this by remodelling existing methods on household vulnerability into new ones, by way of using different existing indexes or comparative approach methods and case study examples as may be suggested in literature. Currently, in the South African context, there is a dearth of knowledge in this area and a distinction has not been clearly established on how to mitigate and adapt to the vulnerability context of informal and formal households in predominantly gold mining regions which are prone to several types of disaster. This scenario has resulted in current measures or actions taken by disaster practitioners registering little impact (WLM, 2017/18 & 2011/12, Mathema, 2011, Murray, 2009, COGTA, 2005).

These disasters and environmental risks are unique to households residing around mining areas (WRDM, 2018/19, Koen *et al.*, 2017, Bhebhe, 2013, Coetzee *et al.*, 2013). Already urban townships are engulfed with challenges that have become standard as highlighted in this chapter. These are in the form of high levels of poverty and unemployment, lack of access to basic services, limited education and income opportunities, high crime rates, and growing numbers of informal settlements. These challenges imply that already households in these urban townships are vulnerable to disaster risks by virtue of having limited assets. The literature, as highlighted earlier, indicates that local socioeconomic circumstances of households exacerbate vulnerability levels. More so, households residing adjacent to mining sites, face several environmental disaster risks, among them, dolomitic and sink hole conditions, mercury metals water and air pollution, land degradation, dust, dam tailings, acid mine drainage, and compromised health, particularly respiratory illnesses. Thus, the interaction of local context/ socioeconomic circumstances of the area with negative environmental activities exacerbate the disaster risk, creating unique conditions.

It is envisaged that findings in this study will help disaster practitioners to effectively target households that are most vulnerable to disaster risks in future. This study will, hopefully, contribute to better and more effective targeting of public resources and programmes, the formulation of effective interventions, and better evaluation of policies. By using the findings of this study vulnerable groups can be identified, coping strategies implemented, and household vulnerability methods remodelled to cater for other critical variables that have not been included in past studies.

Coordination and integration of all role players are prerequisites for effective disaster risk management and proper management of disasters, not only in relation to the spheres of government, but to including all role players, namely, nongovernmental organisations (NGOs), community-based organisations and the private sector. The complex nature of every form of disaster requires this extended scope on consultation and collaboration. Disaster management needs to be dealt with as a management function rather than as an emergency rescue service, and every role player has a unique task to perform. A multidisciplinary approach is required, with the community as the main focal point in order to better understand and measure their vulnerabilities. This study will hopefully benefit all the respective role players by offering policymakers advice on development of interventions, fast tracking of the process of decision-making, improved planning and coordination, as well as on prevention, mitigation, preparedness, response and resilience to every form of disaster risk.

## **1.11 CONCLUSION**

This chapter introduced the comparative analysis of the vulnerability of informal and formal households to disaster risks using Bekkersdal in the West Rand gold mining region as a case study. The chapter provided some background orientation on the study site and on studies on disaster risks in formal and informal households. The research gap that was to be filled by this study was established. The need to establish the specific drivers of disaster risks to households residing in the formal and informal areas of Bekkersdal, in this gold mine region, was set as a key aim. It was determined that research on gold mining disaster risks in this region and on the experience of communities regarding these and related risks, was seriously lacking. This was followed

by setting of the research questions, objectives and a research design that is responsive to the research gap was outlined.

A sampling method was chosen with primary data collected through a questionnaire administered in a sample taken from households in the formal and informal settlements of Bekkersdal. The questionnaire enabled the eliciting of insights on disaster risks faced by households residing next to mines in Bekkersdal. Lastly, the limitations of the study, valued ethical considerations and the significance of the study were discussed.

Overall, the study should bear testimony to the fact that local socioeconomic and environmental context exacerbates vulnerability levels of households. More so, the situation is unique for households residing next to- or surrounded by mining activities as the negative impacts to those mining activities have disastrous environmental impacts. Responses to the challenges faced by these households can therefore not be business as usual. Thus, response strategies need to be tailor made to the known vulnerability of households residing in formal and informal settlements, more so for households residing in (gold) mining areas.

Therefore, the following chapter will focus on the review and understanding of the conceptual and theoretical frameworks relevant to disasters and disaster risks, and the vulnerability of households in both formal and informally settled areas.

## CHAPTER 2

### CONCEPTUAL AND THEORETICAL FRAMEWORKS ON DISASTERS, DISASTER (MINING) RISKS AND VULNERABILITY

In many countries, disasters have significantly reversed several economic and social gains. Worldwide there is an unprecedented increase in the frequency and severity of disasters. This is due to, among other things, land degradation, rapid urbanisation, globalisation, poverty and climate change. In the past four decades alone, disasters have caused more than 3.3 million deaths and cost 2.3 trillion dollars in economic damages, with over 4.4 billion people left injured, homeless and displaced (UNSDIR & CRED, 2018 Gencer, 2013, Peduzzi 2019). Not only that, the COVID-19 pandemic in the year 2020 has exacerbated the impact of disasters and the vulnerability of countries and their respective economies, with over 3 million positive cases and over 200 000 deaths recorded in the month of March 2020, respectively (Pak *et al.*, 2020). As of 3 November 2020, COVID-19 statistics in South Africa stood at over 700 000 positive cases and 19 000 deaths, according to a National Department of Health press statement (2019).

Disasters have pushed millions across the globe further into poverty and exacerbated inequalities. In 2002, the former Secretary General of the UN, Kofi Annan, summed up the drivers of disasters by noting that:

*Communities will always face natural hazards, but today's disasters are often generated by, or at least exacerbated by human activities. At no time in human history have so many people lived and clustered around seismically active areas. Destitution and demographic pressure have led more people than ever before to live in floodplains or in areas prone to landslides. Poor land use planning; environmental management; and lack of regulatory mechanisms both increase the risk and exacerbate the effects of disasters.*

In South Africa, and in the area under investigation in this study, research has been conducted on the negative environmental effects of mining activities in surrounding communities. Findings show that mining activities are associated with negative environmental outcomes which damage the lives and health of people, as well as their livelihoods. Seymour (2005), Liefferink and Van Eeden (2010) described these effects thus:

*Digging into earth to provide the materials for the community's material needs is an honourable and rewarding occupation. It is also one which exposes participants to considerable risks (Seymour, 2005).*

*... the effects of mining activities in the West Rand Gold fields by acid mine drainage have been described as the greatest environmental injustice in the mining sector (Liefferink & Van Eeden, 2010).*

The devastating effects of disasters have driven victims, civil society organisations, policymakers, politicians and scholars, to seek a deeper understanding of what makes a disaster, why disasters take place and the full impacts of disasters. Attempting to answer such questions lends to the subject of disasters a multidisciplinary texture (Pradhan, 2016, Costella & Oyadiya, 2014, Hallegatte & Przyluski, 2010, World Bank 2010, Baker 2009, Alwang *et al.*, 2002, Health Disaster Management, 2002). A historian would probably trace the historical patterns of disasters, while an economist would probably look at the costs and benefits of disasters; yet a civil engineer would look at the structures that can withstand a disaster, and a sociologist would be keen to understand about processes at work in a society when a disaster strikes. Yet, the ultimate goal of all these interest groups is to understand the causes and effects of disasters, and furthermore get to the practical steps for reducing disaster risks. To help communicate the mass, and sometimes, complex information on disasters to the public, policymakers and scholars have organised the reality of disasters into a number of coherent conceptual and theoretical frameworks. Although different disciplines have applied their theories to the study of disasters, these frameworks have one thing in common; they are all derived from evidence-based generalisations of the intricate reality of disasters. Literature on disasters is replete with concepts that speak to key aspects of disasters. The main concepts that underpin disaster narratives include; hazards,



disaster risk, exposure, vulnerability and resilience. These concepts are intricately related.

The purpose of this chapter is to review some prominent conceptual and theoretical frameworks that underpin disasters, disaster risks and vulnerability, especially as they relate to environmentally brittle mining risk areas and their surroundings. Understanding these concepts was critical for the study as it paved the way for, among other things, a deeper understanding of the essence of disasters and disaster risks. Similarly, with vulnerability, existing frameworks provide a deeper understanding of its broader meaning, its drivers, and why levels of vulnerability differ between different social groups. In the following subsection the theoretical frameworks that underpin the disaster and disaster risk concepts, are discussed.

## **2.2 CONCEPTUAL ANALYSIS: DISASTERS, DISASTER RISKS AND DISASTER MANAGEMENT**

### **2.2.1 Disasters**

The notion of disasters means many things to different disciplines. Some definitions take a quantitative approach while some follow a qualitative dimension. Based on their experience in dealing with disasters, the World Health Organisation (WHO) and the Department of Cooperative Governance and Traditional Affairs (COGTA) have perhaps two of the most comprehensive definitions of disasters. WHO define disasters as ‘an occurrence disrupting the normal conditions of existence and causing a level of suffering that exceeds the capacity of adjustment of the affected community’ (WHO, 2002:4). COGTA defines disasters as ‘a significant disruption of the life of a community involving widespread human, material, economic or environmental losses and impacts that exceed the ability of the affected communities to cope using their own resources’ (COGTA, 2015:4).

There are two key things to note from these definitions. First, there should be an occurrence, which disturbs the normal way of doing things. In other words, there should be a hazard that disrupts the normal trajectory of life. Secondly, and on the other side of the equation, there is the affected community that has no capacity to withstand the impact of a hazard. Hazard is defined as a human man made and natural event that

may adversely affect life or infrastructure to the extent of resulting to a disaster (WHO, 2002, Modica and Zoboli, 2016). These hazards (earthquake, industrial events, volcanic eruptions, tropical storms, fire, floods) are an event that may affect a particular point at various times (Modica and Zoboli, 2016,). The Johns Hopkins and the International Federation of Red Cross and Red Crescent Societies (2008) further makes a distinction that only when these hazardous events affect community or population or infrastructure that they become disasters through loss of life or destruction. The combination of a hazardous event on one hand, and a community lacking sufficient capacity to deal with a hazard gives rise to a disaster. Islam *et al.*, (2012) notes that disasters denote a meeting of two opposing forces, that is, vulnerability and hazard. Similarly, the Inter-American Development Bank (2003), define a disaster as some loss due to hazard. In this case, the hazardous event affects a community that is unable to cushion itself from the impacts of the hazard and is unable to recover with its own resources. In other words, a hazard befalls a community that has no means to escape the impact and alters the way that the community functions (International Panel on Climate Change, 2012). As such, disasters render communities unable to cope and adapt to the disaster impacts (UNISDR, 2013, Gallegos 2011, Mitchell 1999). The Global Assessment Report (2019), concurs with the notion that disasters disrupt livelihoods and the household's means towards attaining basic wellbeing, resulting in households being unable to cope on their own, that is a lack of capacity.

It is within this context that, Thywissen (2002), Yodmani (2002) argue that there has been a paradigm shift from disasters being seen as extreme events resulting from natural factors only to disasters being seen as manifestations of unresolved developmental challenges such as unplanned urbanisation and population growth. Cardona (2011), summarises disaster as a process that is prompted by either the natural or anthropogenic factors that interact with risky events causing disruptions in the normal functioning of the community. Thus, disasters are viewed as severe or emergency disturbances towards the functioning of the community, which in turn results in communities being unable to cope using only their own resources (UNISDR, 2015, Raheem *et al.*, 2013, Menzel & Baker, 2009, UNISDR, 2009, Morrow, 1999). That is, disasters can be explained by the community's contextual factors. Therefore, disasters are complex and include those caused by natural events and human made disasters

(Tearfund, 2011, Birkmann, 2007, Wisner *et al.*, 2004). Thus, disasters are also by-products of social, political, economic and environmental factors. For instance, there are mining disasters that have occurred in countries such as South Africa, Australia and USA, Zambia, Chile and Canada, that have been man-made. These disasters have been in the form of fires, explosions, flooding, tailings, shafts, ground collapse, toxic gas and stockpiles (Seymour, 2005). Recently, the collapse of the mining dam which caused the Vale tailing disaster in Brazil is a clear example of a mining related incident resulting in a mining disaster (Heller 2019, Garcia *et al.*, 2017). Seymour (2005) recommends the need for mining companies to develop risk management plans including implementing educational awareness interventions in communities residing in areas surrounding mines.

While mining activities are known for their positive contributions to the economy, jobs and production, they also have negative effects in the form of environmental destruction and negative social impacts on the settlements surrounding the mines (Carvallo, 2017, Marais & Nel, 2016). The negative environmental impacts include mine tailing and acid mine drainage which affect the environment, especially in the gold mining industries where processing releases mercury which contaminates the environment. Damage to ecosystems through mercury contamination in turn affects livelihoods and health of communities. Carvallo (2017), thus recommends that environmental impact assessment should be conducted throughout the life cycle of the mines and the interlinking of mining activities so as to minimise the negative environmental impacts.

Another dimension of the disaster concept was presented by both Uitto (1998:7) and Lindell (2013:799) who posited that disasters are a function of three variables; (a) hazard due to a risky phenomenon, for instance floods, (b) exposure to risky events and (c) vulnerability which makes a community susceptible to loss or damage. This description of disasters links hazards and disasters directly as shown in Figure 3. This Figure depicts a hazard as a man-made or natural, progressive or sudden, widespread or localised, mono-causal or multi-causal event that threatens life, health, property or the environment (Van Niekerk & Wilemien, 2016, COGTA 2015 & 2002, WHO, 2002). As can be seen in Figure 3, a number of examples of hazards can be classified within each class of drivers, that is, either man-made or natural-made. These hazards include the COVID-19 which has become a global pandemic and health crisis, resulting in loss

of lives, disrupting livelihood activities and leaving the poor more vulnerable than ever (Pak *et al.*, 2020, Jayaram *et al.*, 2020). Van Niekerk and Wilemien (2016), Johns Hopkins and the International Federation of the Red Cross and Red Crescent Societies (2008), sum it up by noting that when one or more of these hazard events occurs and it overwhelms the responses based on local capacity and results in loss of lives, livelihoods, and damage to property, the environment and infrastructure; a disaster is thus said to have taken place, with communities unable to cope on their own using their own resources.

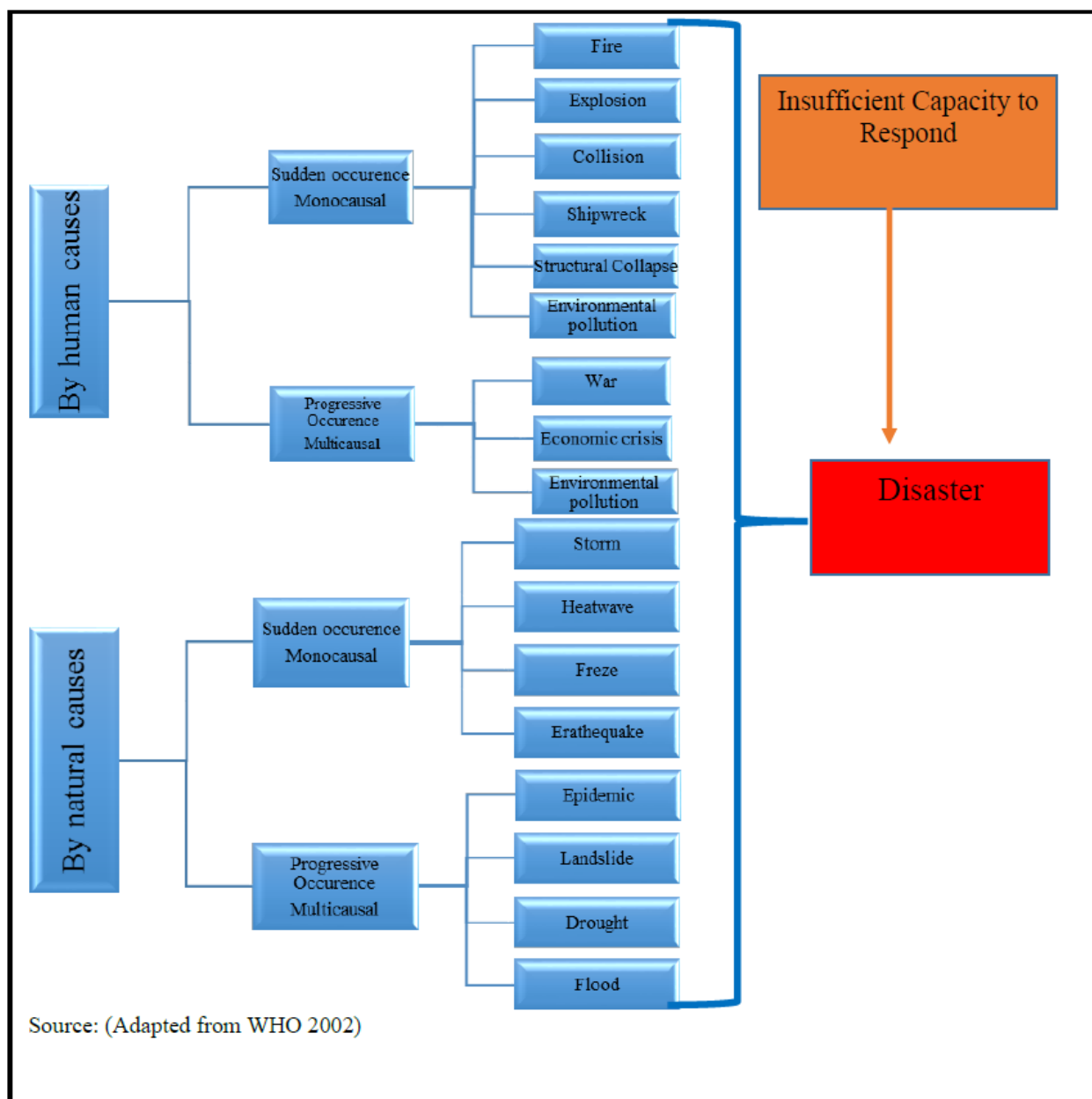


**Figure 3 Hazard classification**  
Source: Adapted from WHO, 2002

In the South African context, the definition of disaster has its origins in Section 37 (1) (a) of the Constitution. The Constitution, Section 24 (a) is quite clear that everyone has a right to an environment that is not harmful to one's health and wellbeing. The policy direction on what constitutes a disaster is provided for in the White Paper on Disaster Management (1999) which observes that in the South African context, disaster events encapsulate, among others, droughts, soil spills, floods, veld fires, mining related disasters, hailstorms, heavy snowfalls and gale force wind (Coetzee & van Niekerk, 2013, COGTA, 2007, Vermaak & van Niekerk, 2004,).

For households living in marginal areas or areas surrounded by mining activities these disaster events are often triggered by, among others, dolomite that form sinkholes, which has been case in the Gauteng province. Equally so these (mining) disasters have negative impacts on people's lives, infrastructure, the environment and economic welfare (Marais & Nel, 2016, Van der Berg, 2015,). Coetzee *et al.*, (2016), further argue that disasters have been part of human existence, however, it is the impacts of these events that have become more pronounced leading to increase in loss of lives, livelihoods and damage to socioeconomic systems.

A study by the National Department of Public Works identified 47 municipalities (out of a total of 257) as partially located in dolomitic areas, with most being found in the Gauteng province within the RWC municipality, where our case study area Bekkersdal is located (Department of Public Works, 2003). The South African Human Rights Commission (SAHRC, 2016) found that mining activities have caused detrimental environmental impacts in communities surrounded by mines. The negative impacts included loss of natural resources due to acid mine drainage, which also affects livelihoods, pollution, dust, and health related conditions, for instance, respiratory illnesses. The report recommended that appropriate measures be put in place to address and minimise negative effects of mining activities in communities. Such measures include the protection of natural resources, the rehabilitation of mine tailings and sustainable mining which minimises negative impacts.

As elsewhere in the world, the definition of disasters in South Africa has evolved. The disaster act viewed disasters as being progressive or sudden, widespread or localised natural or human caused tragedies or hazards that threaten life, health, property or

environment (COGTA, 2002). Currently disasters are defined as a significant disruption of the life of a community involving widespread human, material, economic or environmental losses and impacts that exceed the ability of the affected communities to cope using their own resources (COGTA, 2015). The disaster act viewed disasters as largely driven by human actions, and to a lesser extent an act of God (Willemien & Van Niekerk, 2016, Van Riet, 2009, Failing, 2008). Coetzee *et al.*, (2016), argue that disasters have always been a part of life and what has changed over the years is their intensity and frequency, leading to loss of lives, livelihoods and ecological systems.

It is important to note that the various local or international definitions of the term disaster are not universal (see Pradhan, 2016, Rodriguez *et al.*, 2014, Hallegate & Przyluski, 2010, World Bank 2010, Menzel & Baker 2009, UNISDR 2009, Health Disaster Management 2002, Style 2002).

Therefore, the definition of disaster is not mutually exclusive; as it is dependent on the discipline within the context of which it is used. Rodriguez *et al.*, (2014) further add that it doesn't mean existing definitions are the only ones or disaster definitions have been exhausted, but current definitions have simply been the ones that have occurred frequently in various disciplines and are the most pronounced. Despite, the various definitions of the term disaster, the conclusion in the field of disaster research states that disasters are complex and they affect the collective, rather the individual, with the loss exceeding the capacity of communities to cope on their own (Menzel & Baker, 2009). Therefore, firm understanding of disasters is critical for sustainable development and for human beings to appropriately respond to the threat and impact of disasters. In studying disasters, it is important to understand what disasters are and why they occur. Theories of disasters help expose the origins of disasters and in the application of mitigation strategies and choice of appropriate responses among many alternatives. The next subsection discusses theories on disasters.

### **2.3 THEORETICAL FRAMEWORKS TO DISASTERS**

Disaster scholarship has evolved over years, from being a mono-disciplinary subject to increasingly becoming an inter- and multi-disciplinary one. There is also some general agreement among scholars that the complex interactions of disaster risks with the causes and consequences of vulnerability should be treated as inter- and multi-

disciplinary. The growing consensus is that the concepts of disaster and vulnerability should be framed in a manner that blends many conceptual facts and theories of the natural and social sciences. For example, according to Mileti (1999), “hazard research now encompasses disciplines such as climatology, economics, engineering, geography, geology, law, meteorology, planning, seismology and sociology”. Cutter (2003) shares the same sentiments, that the study of disaster and vulnerability is “an interdisciplinary endeavour and spans the divide between the social, natural, engineering and health sciences among others”. Whereas Chipangura *et al.*, (2019) summarise that framing disasters gives acknowledgment to the various components of disasters that should be integrated so as to be able to address disaster issues and approaches holistically and effectively. In fact, how disasters have been framed has been the cause of various policy and implementation failures. Chipangura *et al.*, (2019) describe this problematic framing as “...select some aspect of perceived reality and make it more salient such that it promotes a particular definition, causal and interpretation as well as moral evaluation/recommendation”. This implies that disasters have been diagnosed according to a particular frame (hazard or socioeconomic and environmental context) and therefore treated only as such. Pathias *et al.*, (2013) are of the view that for disaster reduction mechanisms to be effective and address the cause ...measures should also include ‘peoples own local conceptions of reality in terms of how they anticipate, prepare for and respond to disasters. Chipangura *et al.*, (2019) are of the view that when a community is given an opportunity to deliberate on issues that affect them such as the disaster risks, there is likely going to be buy in, which in turn is going to translate into effective policy design successful implementation of disaster risk reduction measures.

Therefore, approaching disaster and vulnerability scholarship from multi- and interdisciplinary perspectives has become a necessity because of:

- The frequency and diverse nature of disasters. For example, at any one point we can have natural hazards (for example earthquakes, landslides, drought, wild fires), anthropogenic-related incidents (for example railroad derailments, industrial/ mining explosions, infrastructure failures), biological threats (for example foot and mouth disease, COVID-19, avian flu) and intentional hazards (for example plane hijackings, suicide bombings), which require disaster

practitioners that are skilled and trained in different disciplines and skills to address them.

- Disaster risk management requires many functions across the many phases of disasters. In this regard, multidisciplinary skills are required. For example, a multidisciplinary approach is required to manage hazard mitigation, vulnerability assessments, planning, warnings and evacuations, to name but a few.
- Lastly, an inter- and multi-disciplinary approach is necessary as each disaster requires many actors, and diverse skills, expertise and experience. Each disaster will require actors from different disciplines, for example the involvement among others, of politicians, economists, meteorologists, engineers, NGOs, land use planners and volunteers. As such, traditional disciplines that are often involved in disaster may not be adequate to address the demands of disasters in the current setting.

The inter- and multi-disciplinary approach to disaster and vulnerability, which is seen in practice, should also apply to research. Inter- and multi-disciplinary research on disasters and vulnerability is not constrained by disciplinary boundaries, but it ensures the integration of methods and analysis from different disciplines to best inform solutions. It generates analysis with better value, and it is apt to giving disaster policymakers and practitioners sustainable solutions. Theories and conceptual frameworks that guide disaster research should ideally be multidisciplinary, hence the subsection below, discussing disaster theories.

### **2.3.1 Disaster Theories**

Many scholars argue that defining disasters by their origin is unhelpful, as there are numerous possible origins. Instead, it is only suitable to classify disasters 'by their general cause rather than by specific origin' (Britton & Oliver, 1991, Rodriguez *et al.*, 2014, Menzel & Baker, 2009). It is pivotal to accurately classify types of disasters to avoid misapplication of mitigation and adaptation strategies. There are four general causes or theories of disasters, namely: disasters as acts of God, acts of nature, joint effects of nature and society, and social constructions. Subsequent subsections discuss



each of these disaster theories, (Chipangura *et al.*, 2017, Pradhan, 2016, White *et al.*, 2001, Tobin & Montz, 1997, Quarantelli, 1998, Kreps, 1998,).

#### **2.3.1.1 Disasters viewed as Acts of God**

This is perhaps the oldest theoretical thinking around disasters, that disasters were God's way of punishing society for transgressing the laws of God. So, a disaster event was beyond science and scope of human influence and no one should be blamed for it (White *et al.*, 2001, Mathúna *et al.*, 2018, Baidhaw 2015, Chipangura *et al.*, 2017). Disasters were seen as part of God's plan and way of dealing with society and individuals that do not observe his laws. Human sin was blamed for disaster events, and human beings had no control of Godly decisions. Accordingly, disasters were framed as 'divine retribution for human misdeeds and failings' (Chipangura *et al.*, 2017). The only thing that human beings could do is to appease God by abandoning their 'evil misdeeds'. The challenge with this theory is that no one will take responsibility for disaster events. Take for example, climate change. It means there is no need to put in place mitigation or even adaptation measures as God would unleash a disaster when people have sinned against him. In many ways, disasters are used as an excuse to avoid responsibility after a disaster occurrence. The greatest challenge of this theory is that society should do nothing to prevent or avoid disasters, nor should society try to mitigate the impact of disasters. The theory fails to respond to the types of disasters that are brought about by the interconnectivity of societies, people or technology which are prevalent in modern day discourses.

#### **2.3.1.2 Disasters viewed as Acts of Nature**

Disasters as acts of nature implies that disasters are natural, or they are caused by natural hazards. In this conception, disasters are a function of the extremes of nature and have nothing to do with human beings (Tobin & Montz, 1997, Chipangura *et al.*, 2017). Advances in science have resulted in more scientific analysis of disasters and attributing them to nature instead of God's creation. Quarantelli (1998), defines a natural disaster as 'an outside attack upon social systems' and disasters are viewed as hazards. Often referred to as the 'hazard centric' conception, here nature is considered a commodity that can be used and manipulated through technical expertise and knowledge (Chipangura *et al.*, 2019). Only the application of natural science is deemed

fit to address disasters. More often these natural disasters are caused by environmental factors which include meteorological (storms and cyclones), hydrological (for example, floods), climatological (for example, extreme weather conditions, drought and wildfires), or biological (diseases, epidemics, infestations, plagues) and geophysical (earthquakes, landslides) events.

According to Quarantelli (1998), the geophysical, meteorological, hydrological and climatological disasters are generally the most frequent and very impactful. In the case of mining, Katpatal and Patil (2010), Bai and Tan (2019) argue that mining activities can have negative disastrous effects which can lead to disaster risks in the form of landslides, surface movements, debris flow, and ground collapse, that in turn affect biodiversity and the wellbeing of households residing nearby. This theory's downfall is that disasters viewed from the perspective of nature regard humanity as powerless victims of 'natural' hazards and thus free from the responsibility of avoiding disasters (Chipangura *et al.*, 2019), which should not be the case as disasters are multidisciplinary.

### **2.3.1.3 Disasters viewed as Joint Effects of Nature and Society**

In this theory, disasters are induced by man. In other words, man does not cause disasters but induces a disaster. Such disasters are thus called unnatural as they result from human acts of omission (for example overturning a bus, conflicts) and commission (such as industrial or transport accidents). The view postulates that a disaster matters if human beings are part of nature and they influence nature. Disasters are caused by humans and occur in or close to human settlements. That is, when natural occurrences take place in places where there are no human beings, then there would be no disasters. Disasters are disasters because there are human beings affected. This theory also encapsulates disasters that are also a result of man's interaction with technology (Kim & Sohn, 2017, Van Niekerk 2014). Hynes (1997), refers to these kinds of disasters as 'mock democracy', which refers to a lack of institutionalised safety mechanisms in place by industries in their daily operative measures. This often results in mining disasters which could have been avoided (Hynes 1997, Watkins & Bazerman, 2003, Machuca *et al.*, 2016; Van Eeden *et al.*, 2008).

#### **2.3.1.4 Disaster as Social Constructions**

As from the 1970s there was a paradigm shift in the way disasters were viewed. The shift was from viewing disasters as a natural phenomenon to the belief that disasters were socially constructed (Chipangura *et al.*, 2017). In the context of this theory, there is no such thing as a natural disaster but socioeconomic imbalances cause disasters. Disasters are largely a developmental issue, caused by socioeconomic factors rather than natural factors. This theory contends that, for example, people die from floods not because of the flood itself, but because of the fragile economic situation and poor governance which result in some people being vulnerable to floods. A disaster is not because of the physical floods, but because some people are located in areas that are susceptible to flooding. The social systems of a place, cause people to live in dangerous places or make risky decisions. Therefore, disasters are 'socially constructed through the interaction of economic, cultural and political processes operating at several different scales' (Chipangura *et al.*, 2017). This means that disasters do not occur on their own, contextual factors play a crucial role. Therefore, this theory states that the socioeconomic, environmental and political context determine the extent of household vulnerability. In disaster risk literature, emphasis has been placed on social, political and economic exclusion of the poor and powerless, which makes some people in a society vulnerable. While the conception of disasters viewed as socially constructions has played a major role in disaster literature in terms social change and vulnerability, where these contextual factors are lacking, policymakers and disaster practitioners have often failed to take these factors into account when making policies and seeing to the implementation thereof (Pathias *et al.*, 2013, Chipangura *et al.*, 2017).

In South Africa, people settle in informal settlements not because they have a choice, but because they have no means to locate themselves in better places or they do so in order to be closer to areas work, such as mining companies (Cronje *et al.*, 2013, Van Niekerk 2016). They locate in informal settlements because they are poor or because they do not have the political or economic power to make different choices. The well to do will obviously live in well-planned formal settlements or in areas that are less susceptible to hazards because they have the economic power to live in such places. Informal settlements face many risks, such as fire, flooding, mining effluents and disease, among others (Abunyewah *et al.*, 2018, Williams *et al.*, 2018). Thus, disasters

should be understood in terms of people's level of vulnerability, than relying on the physical perspective alone.

People's level of vulnerability is determined by among others, their socioeconomic and environmental circumstances, such as gender, race, class, ethnicity, caste, income, seismicity. These socioeconomic features are in turn driven by a number of factors including; demographics, ill-considered economic decisions, conflicts and war, environmental trends, debt crises, national and international political economy, or power relations, to name but a few. These factors define an individual's level of exposure to a natural hazard. For example, one's livelihood and resilience, health and wellbeing, quality of house construction and location, rights and status of civil society all contribute. In South Africa, some studies observe that the negative effects of mining activities on humans is often driven by people's socioeconomic circumstances (poverty, unemployment, poor housing and infrastructure, respiratory illnesses, HIV/AIDS, alcohol abuse, malnutrition, and mental illnesses) (Cronje *et al.*, 2013, Koen *et al.*, 2017, Coetzee & Van Niekerk 2013, Bhebhe *et al.*, 2013).

In Klerksdorp, in the North West province, seismicity was found to be causing infrastructure collapse. In this case, building around the area rendered such households vulnerable to disaster risks. Another case in point is the Kloof Gold mine located in Westonaria town, where Bekkersdal is located. The town has experienced significant seismic events which have had negative environmental impacts (Ngcobo, 2006:262). These negative environmental impacts affect the levels of groundwater which is used for agricultural purposes and cause the formation of sinkholes which endanger infrastructure, especially houses built in the area. In addition, sinkholes are used as waste dumps. Eisler (2003), argues that households are exposed to health related risks such as respiratory illnesses, and mercury metals are found in water which is also used for drinking water in the area. Koen *et al.*, (2017), Van Eeden *et al.*, (2008), Liefferink (2019), suggest that mining activities which pollute water and cause acid mine drainage in the Upper Wonderfontein spruit (WFS) where Bekkersdal informal settlement is located, affect the wellbeing of Bekkersdal residents. Other hazards that pose environmental risks include mining related pollution and land pollution as a result of litter and untreated sewerage.

According to this theory (disaster as social constructions), mitigating the risk of hazards, requires that certain development issues are addressed. It requires interventions that will reduce the vulnerability of society. Such interventions include ensuring that there is good governance, less corruption or that robust infrastructure is built alongside strengthening the economy. It requires investments that will ensure there is social inclusion and policies that foster the eradication of poverty and inequalities. In the context of this thesis, where the focus is on comparing the vulnerability of formal and informal households to disasters in especially dolomite prone (gold) mining regions, the last two theories (that is, disaster as joint effects of nature and society, and disaster as social constructions) were considered as too closely approximate reality. A case in point are the informal sector dwellers who find themselves in this sector not because of choice, but because of their socioeconomic, environmental and political circumstances (Van Niekerk 2016, Costella & Oyadiya 2014, Abunyewah *et al.*, 2018). They reside in informal settlements because they lack resources and means to move into the formal settlements. As a result of their socioeconomic, environmental and political circumstances, they find themselves in the vulnerable informal housing sector. They are therefore vulnerable to disaster risks due to their disadvantaged position. Their limited means compel them to locate in areas prone to disasters and even to construct houses that will not withstand hazards. Thus, it is their level of vulnerability that explains their high risk to disasters. In terms of solutions it is important that policies deal with and address their vulnerability, by among others, improving their socioeconomic and environmental circumstances (Abunyewah *et al.*, 2018, Williams *et al.*, 2018).

Classifying disasters into different categories is key to identifying suitable mitigation and adaptation strategies. The different theories discussed above assist in identifying different mitigation and adaptation measures. Scholars (Kreps, 1998, Quarantelli, 1998) have questioned the need to separate the causes of hazards and have different theoretical explanations of disasters. In support of their stance, they argue that natural events modify human activities and human activities influence natural events, while the consequences of disasters are the same. Several others, among them Wisner *et al.* (2004), De Leon (2006), Birkmann (2007), Beccari (2016), Van Niekerk (2016), also support the argument that disasters should be viewed broadly, stating that disasters do

not occur as a result of natural causes but are also a result of the socio-economic and environmental factors.

In this study, the view was maintained that even if some of the consequences of disasters are the same, there is a need to classify disasters differently in order to deploy appropriate mitigation and adaptation strategies. A proper diagnosis of the causes and consequences of disasters will ensure that appropriate mitigation and adaptation strategies are deployed. Closely linked to the concept of disaster, is that of risk. Every disaster starts with a risk, whether known or unknown (Thywissen, 2002). In order for a disaster to take place, there are prior conditions that would exist. The condition is the risk, whether known or unknown, where the risk can be attributable to among other things, the hazardous events and susceptibility to injury or loss. Communities and their livelihoods are always exposed to these risks (UNISDR, 2008). The next section provides a conceptual definition of disaster risks.

## **2.4 DISASTER RISK**

Communities and their livelihoods are sometimes exposed to forms of disaster risks (UNSDIR, 2013, Gallegos, 2011, UNISDR, 2008, Birkmann, 2007, Mitchell, 1999). In the context of disasters, risk simply denotes the possibility of a future loss due to interactions between natural and human made hazards or vulnerable conditions (De Leon, 2006). That is, disaster risk is due to the potential occurrence of a hazard as well as susceptibility of people to injury or loss.

Disaster risk is a collective risk or a risk that becomes a threat to all those exposed and vulnerable (Inter-American Development Bank, 2005, Raheem *et al.*, 2013). Thus, disaster risk is a product of three fundamentals; exposure to risks, its frequency and the vulnerability level or capacity to cope (UNDP, 2004, Vatsa, 2004, Gaillard & Kelman, 2011, Islam *et al.*, 2012, IPCC, 2012, Birkmann, 2007, Madica & Zoboli, 2016). According to the Global Assessment Report (2019), disaster results elements are determined by their occurrence, amount and impact to the households.

The concept of disaster risk has evolved over time and that disaster risk takes place when a hazard interfaces with vulnerability or a community that is unable to cope with the disaster impacts using its own resources. Peduzzi (2019), notes that the interface

between hazards and exposure or incapacity of community to cope on their own is further compounded by environmental changes in the form of demography, social and economic use of energy and natural resources, as well as physical changes of the earth climate. Accordingly, Chen (2015), Islam *et al.*, (2012), WHO (2002), Raheem *et al.*, (2013) define disaster risk using the following function: that is disaster arise as a result of mixture or a combination of hazards, vulnerability and the incapacity to reduce those risks associated with, as per the mathematical equation below;

$$\text{Disaster} = \text{hazard} + \text{vulnerability/capacity}$$

The meaning of disaster risk is sometimes confused with that of vulnerability. Baker (2009), contends that these concepts are distinct. The former is about future risks, while the latter is about materialisation of the risk. For instance, if a community is at risk, some measures can be taken prior to mitigate the risk, while if they are vulnerable, actions can be taken after the risk to reduce the vulnerability. Thus, disaster risk is a socially constructed process, while vulnerability is a dynamic process. However, Brooks *et al.*, (2005) argue differently and are of the view that there is a relationship between disaster risk and vulnerability. That is, risk is the probability of an occurrence of an event that acts to trigger a disaster with undesirable outcomes, and it is mediated by the sensitivity or vulnerability of the exposed systems. In short, they view risk as a function of vulnerability. Vulnerability depends on the context and the factors that make a system vulnerable to a risk (Thywissen, 2002, Cannon, 2015). That is, the socioeconomic and environmental factors intensify the risk and vulnerability of a household in cushioning themselves against disaster event (Van Niekerk *et al.*, 2016, Peduzzi, 2019, Williams *et al.*, 2018).

Figure 4 shows the relationship between disaster risk, vulnerability, exposure and resilience. Smit and Wandel (2006), view the concepts of vulnerability, adaptation, resilience, exposure and sensitivity as interconnected. In Figure 4, a disaster risk is viewed as a result of hazard, vulnerability, exposure and resilience. For instance, vulnerability reflects that there is exposure and sensitivity to a particular hazard and sensitivity to a disaster event which tests the ability of communities to cope.

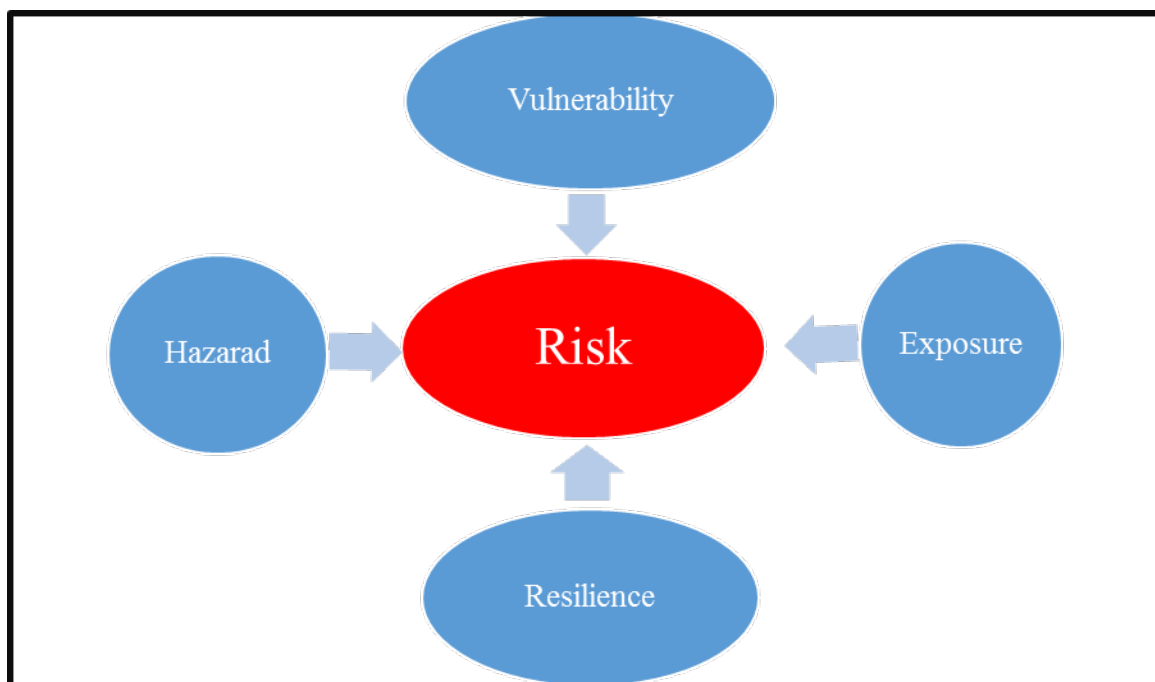


**Figure 4 Risk relationship**

Source: Adapted from Thywissen (2002), Cannon *et al.* (2015); Smit and Wandel (2006).

Scholars like Birkmann (2007), Cardona (2011), Palliyagur (2014), Karim (2017) eloquently summarise the concept of disaster risk. They note that by adding ‘risk’ to ‘disaster’ it means disaster is a product of the interaction of exposure to the risk, vulnerability to damage, hazard event and capacities of people and institutions to cope with the impacts (see Figure 5 below). Further, disaster risk is due to collective risk that households become predisposed to as a result of the socioeconomic and environmental factors (Inter-American Development Bank, 2005, UNISDR, 2015a, UNISDR, 2009, Birkmann, 2007, Vatsa, 2004, UNDP, 2004).

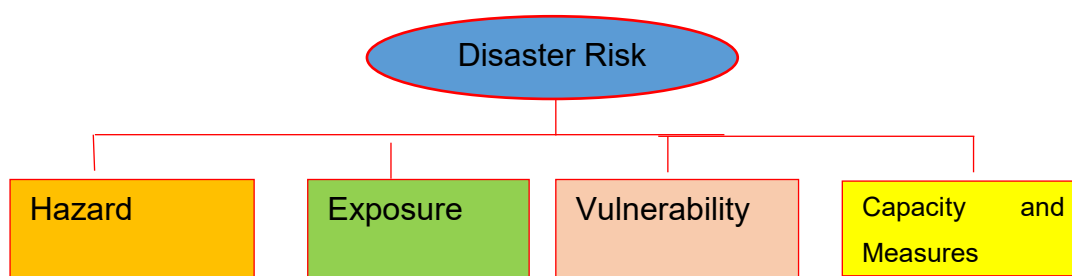


**Figure 5 Disaster risk**

Source: Adapted from Birkmann (2007), UNSIDR (2015), Vatsa (2004) and UNDP (2004).



In the South African context, disaster risks also refer to the probability of expected losses (Benjamin, 2008). These losses are in the form of deaths, damage to property, livelihoods as well as the physical injuries arising from the interaction between human and natural activities (Benjamin, 2008, Vermaak & Van Niekerk, 2004). Furthermore, disaster risks have been increasing in the country experienced as floods, tornadoes, hailstorms, heavy rains and winds, droughts, veld fires, informal settlement fires, and human induced disasters such as soil spills and mining related incidents, among others, (Failing, 2008, Vermaak & Van Niekerk, 2004, Van der Berg, 2015). These disaster risks are attributable to a combination of hazard and vulnerability processes in various aspects of infrastructure development, urban growth and settlement densification, and sinkholes as a result of mining in dolomitic areas (Van der Berg, 2015, Failing, 2008). Disaster risks have an impact on lives of people, their environment, infrastructure, and economic and social development.

As per the definitions of disaster highlighted above, the conclusion is that a disaster causes disruptions, injuries, and loss of lives, among others. Therefore, the disruptions that are caused by these disasters are an outcome of vulnerability (Rodriguez *et al.*, 2014, Adebimpe, 2011, Willemien & Van Niekerk, 2016). The next subsection defines and discusses vulnerability.

## **2.5 THEORETICAL FRAMEWORKS: VULNERABILITY**

There is no universal theory on vulnerability (Hufschmidt (2011: 623). In many instances, vulnerability has been shaped by three schools of thought: the human ecologists school (sometimes called the Chicago school or behavioural paradigm) (Smith 2004), the Anthropology/Sociology school; and the structural paradigm approach. The human ecologist school puts emphasis on human adjustment as the core element in reducing the negative impact of disasters. It places emphasis on human activities in reducing the negative impacts of a natural hazard. In this paradigm, if there are disasters, human beings adjust the utilisation of their resources to minimise the negative impacts. Losses from disasters occur when human adjustments are overwhelmed by unusual natural processes. Adjustments are purposeful actions like

building a dam wall to avoid floods or designing a house to resist earthquakes (Kates, 1985).

The human ecologist approach views adaptation as a “process of coevolution between an organism and its environment” (Hufschmidt, 2011:624). According to this school of thought, to minimise household vulnerability and to avoid pitfalls of using one adaptation method, response should encompass many activities (Mitchell, 1999). The key implication of the human ecologist approach is that natural disasters are a result of false human adaptation rather than natural forces only. Secondly, this school of thought implies that human beings need to adapt to reduce the potential negative effects of natural disasters.

In the sociology/anthropology context, vulnerability is determined through the identification of vulnerable groups to the disaster risks (Alwang *et al.*, 2001, Moret, 2014). These vulnerable groups range from, among others, children, female headed households, the elderly and people with disabilities. The theory acknowledges the role of social institutions and power in creating vulnerability. That is, the higher the levels towards social integration of the community, the easier it becomes for the community to absorb the consequences of disaster (Cardona, 2011). Usamah (2014), Alwang *et al.* (2001), IRS (2012) emphasise the point that households, especially the poor become vulnerable due to limited social capital and political disenfranchisement, which hinders their access to relief services. In this school of thought, social class indicates access to resources such as employment, income, savings and educational levels.

Vasta (2004) is of the view that people in low income groups often find it difficult to secure financial resources and technical skills, and women are disproportionately affected by disaster events. Race and ethnicity are closely related to the material losses experienced and differential abilities in acquiring resources for recovery. The approach also examines the ability of households to cope with or be resilient to the disaster risks. This is where, Sutherland *et al.*, (2005) argue that the ability of the community to prepare or cope or recover is determined by community features or conditions such as wealth, equality, political and social stability, access to infrastructure, institutional support and social capital. Vatsa (2004) is of the view that assets are the means of

resistance to the impact of a disaster and as such household resilience is closely linked to asset ownership.

The structural school of thought views vulnerability is a result of the rigidities of socioeconomic and political structures. According to the structural school of thought, it is the social, economic, cultural and political context in which people are that determines their vulnerability. The three schools of thought just described have influenced various vulnerability explanatory approaches. These explanatory models of vulnerability include the 'Pressure and Release' (PAR) model (Wisner *et al.*, 2004), the Access model, and the Sustainable Livelihoods Approach (SLA) by Chambers and Conway (1992). The next sections discuss these three models.

### **2.5.1 Pressure and Release (PAR) and Access Models**

According to Raheem *et al.*, (2013) vulnerability is made up of three stages; underlying causes – that interact and cause vulnerability; dynamic pressures – which are socioeconomic changes that lead to unsafe conditions such as lack of resources or basic services, and in turn, the unsafe conditions that result in people being exposed and rendered vulnerable to disaster risks. Therefore, by using a Pressure and Release (PAR) model, Wisner *et al.*, (2003, 2004) explain how a disaster occurs and how vulnerable communities are affected. The PAR model is based on the premise that a disaster is the connection of two opposing forces; those processes that generate vulnerability and those of natural hazards. Wisner *et al.*, (2003) are of the view that the evolution of vulnerability is caused by *root causes*, *dynamic pressures* and *unsafe conditions* which are all connected to disaster processes. The *root causes* relate to the allocation and distribution of resources among the social groups which give rise to vulnerability, that is the economic, demographic and political underpinnings. *Dynamic pressures* include epidemic disease, rapid urbanisation, violent conflicts and structural adjustment programmes, which translate the root causes into *unsafe conditions*, the third aspect of vulnerability. *Unsafe conditions* refer to hazardous locations, inability to afford safe buildings, lack of effective protection from government, and engagement in dangerous livelihoods.

In essence, the PAR model outlines a hierarchy of causal aspects which constitute preconditions for a disaster. However, the PAR model does not explain why other groups suffer more than others and it does not explain changes that occur before and after a disaster event occurs. Hence the extension of the PAR model, through what is called the ACCESS model. The ACCESS model explains in detail what happens to people when disaster strikes, as well as their access to capabilities, assets and livelihood resources. In the main, the ACCESS model notes that those people that have better access to information, resources and social networks to mobilise resources are less vulnerable to hazards and have the potential to recover quickly from the impacts.

In the main, it has been stated that there is no universal theory on vulnerability, however, the schools of thoughts towards vulnerability originate from economics, sociology/anthropologist and disaster risk management disciplines (Moret, 2014, Matyas & Pelling, 2012, Fang *et al.*, 2016, Alwang *et al.*, 2001). These schools of thoughts are closely linked to the key frameworks and approaches developed in the 1990s so as to help understand root causes to vulnerability, namely the Pressure and Release and Access models and the Sustainable Livelihoods Approach. These approaches are discussed in the following subsections.

#### **2.5.1.2 Pressure and Release (PAR) Model**

The PAR model plays an important role in framing disaster vulnerability research (Blaikie *et al.*, 1994). The PAR model views disaster risks as the interaction of two opposing forces; those processes that generate vulnerability and those that generate hazards. According to the PAR model, the pathway of vulnerability progresses from 'root causes' (such as political and economic systems) to 'dynamic pressures', and to 'unsafe conditions' (Hufschmidt, 2011:643; Raheem *et al.*, 2013). The main aim of the PAR model is to explain the pathway to vulnerability (Adger, 2006). According to Adger (2006), vulnerability arises from the pressures coming from geological conditions (root causes) which in turn cause unsafe conditions. The 'root causes' constitute the underlying causes of vulnerability and include economic, demographic and political processes as well as the power relations and structures between government and citizens. Communities surrounding mining activities are vulnerable because they often

have limited or no employment or income opportunities. Their ability to cope with disaster risk impacts is weak due to the pre-existing settlement patterns and poor social conditions (Morrow, 1999, Cronje *et al.*, 2013). These communities are located in marginal areas and in the main, they reside in shacks constructed on dolomite, and sinkhole formations exacerbate their vulnerability (Coetzee & van Niekerk, 2013, Winde & Stoch, 2010). The political processes and power relations involve social cohesion which households can draw on to mitigate the effects of disaster risks. When these factors are lacking, the communities become vulnerable. In a nutshell, root causes refer to distribution of power, wealth and resources. Limited or no access to resources impacts on households' daily lives and consequently on their vulnerability. That is, access to resources determines how resilient people are. Households that are poor financially and have limited livelihood options also tend to have limited voice.

Dynamic pressures (processes that causes negative effects towards unsafe conditions) constitute factors that cause household insecurities such as rapid and unplanned urbanisation, deforestation or environmental degradation due to mining activities, and population growth (Van Niekerk, 2013, Van Eeden, 2009). For example, Van Eeden (2009) notes that increased urbanisation which increases in tandem with mining activities results in households residing and working very close to mine waste dumps. Gaillard and Kelman (2011) note that dynamic pressures fall in between the societal deficiencies, such as lack of training, resources or mitigation measures, and the lack of socioeconomic, environmental and political processes. Adger (2006) posits that vulnerability is caused by the interaction between social dynamics within the social-ecological system. Therefore, measures of vulnerability need to reflect social processes as well as the material outcomes. 'Unsafe conditions' that precipitate vulnerability include locations that have dolomitic geology or sinkhole formations, buildings that are hazardous, lack of disaster preparedness, engaging in livelihoods that are dangerous to society – such as illegal mining or use of open pits as waste dumps –, and negative mining activities such as blasting, which weakens building structures, all of which render these areas dangerous or risky (Rooparine, 2002, Limborg *et al.*, 2003, Ncube-Phiri *et al.*, 2014, Van Niekerk, 2013, Ngcobo, 2006, Durrheim *et al.*, 2006, Koen *et al.*, 2017, Water Research Commission, 2009, Li, 2018, Van Eeden, 1997, Van Eeden *et al.*, 2008, Bai & Tan, 2019). Gaillard and Kelman (2011) refer to livelihoods as the

resources that can be used to alleviate or dampen vulnerability, which include the five capitals; natural, physical, human, social, economic and capital.

Hynes (1997), Van Eeden *et al.*, (2009) have described the disregard for safety or compliance as a major conduit for vulnerability. A case in point is in the mining sector where compliance with safety conditions is sometimes disregarded resulting in negative consequences to surrounding communities. Hynes (1997), refers to mining disasters as caused by a deliberate disregard of mine safety rules, warnings and procedures by mining companies, and this often becomes the norm, hence the frequency of disasters in the sector. For mines and mining communities to have sustainable mining, there should be net improvement in the ecological, economic and social wellbeing of the local community. Hilson (2002), argues that there is always some conflict between communities and large-scale mining characterised by the opposing imperatives of land for mining versus livelihoods. This conflict is often exacerbated by the unpredictable and often preventable disasters in the form of chemical spillage, collapse of tailings dams and heavy metals leaching. However, compromise with regards to the working environment and the need for protection of livelihoods and indigenous knowledge can be reached through effective communication and consultation between the parties. The three PAR model pathways of vulnerability are summarised in Figure 6.

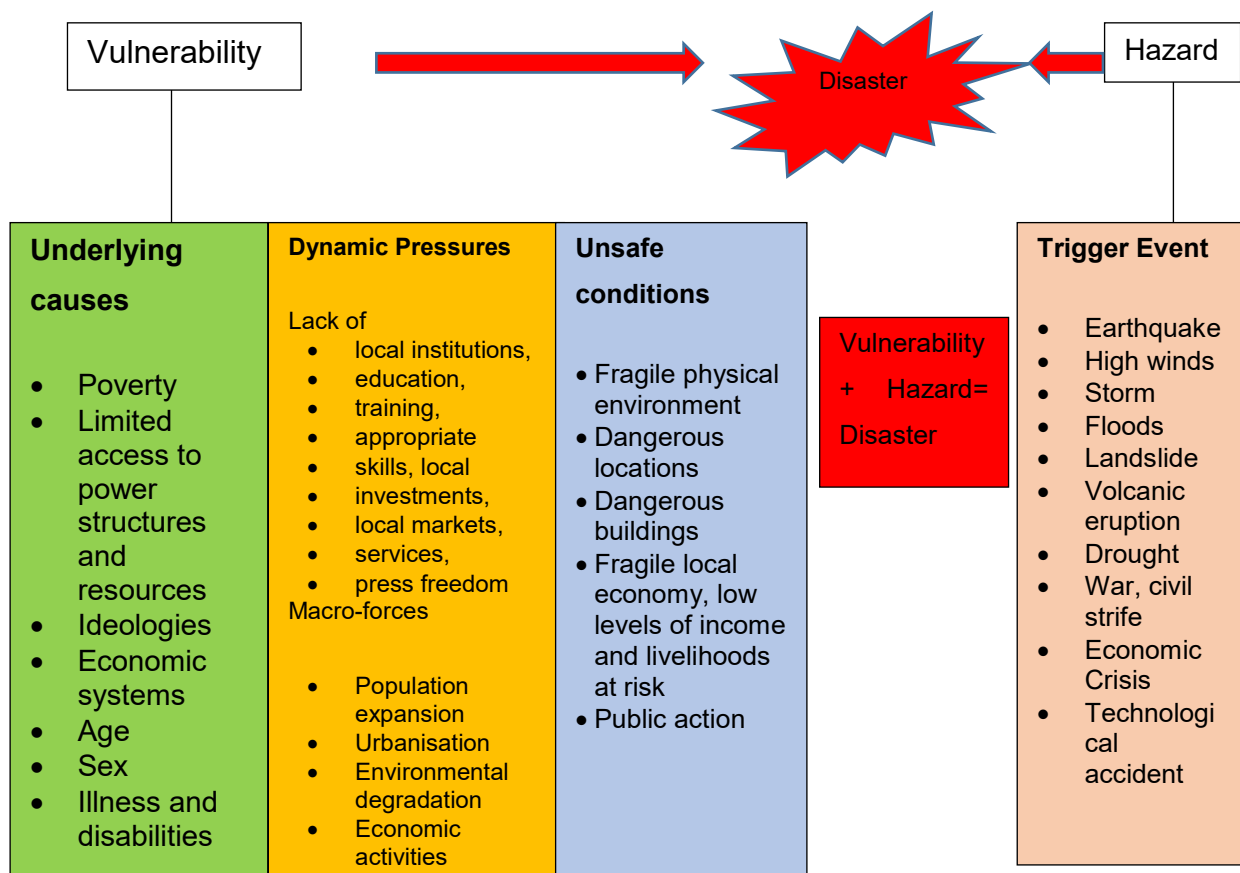


**Figure 6 PAR Model: Vulnerability**

Source: WHO (2002), De Leon (2006), Wisner *et al.*, (2003; 2004), Hufschmidt (2011).

In essence, the PAR model outlines a hierarchy of causal aspects, which constitute preconditions for a disaster. Thus, the PAR model can be used as a tool that confirms concepts of vulnerability from social status to the root causes (Kunene, 2020). However, the PAR model does not explain what causes vulnerability and what measures can be used to reduce the vulnerability (Vatsa, 2004, Adger, 2006). The PAR model has its complementary model in the form of the Access model. The Access model gives more detailed information on what causes vulnerability at the local scale or micro level. The Access model is discussed next.

### 2.5.1.3 Access Model

According to the access model, household livelihoods and hazards clash when geophysical processes severely disrupt daily actions. In such a situation, the household is forced to pursue many adaptation strategies. As in the PAR model, adaptation is a fundamental instrument for reducing vulnerability in the access model. Furthermore, and

as with the PAR model, the access model considers vulnerability as a multidimensional concept. The access model places emphasis on access to resources such as materials, political power or social relations, to explain vulnerability. In other words, vulnerability is dependent on the availability of resources. In the context of the access model, vulnerability is also a function of an individual profile such as the socio-demographic characteristics of a person (age, gender and race). According to Vatsa (2004), households with more resources have the greater ability to reduce the impact of disaster and secure their livelihoods and vice versa.

The access model is very much comparable to another common model; the Sustainable Livelihoods Model, first introduced by the Brundtland Commission on Environment and Development and the UN Conference on Environment and Development. The Brundtland Commission on Environment and Development and the UN Conference on Environment and Development considered achievement of sustainable livelihoods a broad goal for poverty eradication. The next subsection discusses the Sustainable Livelihoods Model.

#### **2.5.1.4 The Sustainable Livelihoods (SL) Model**

The sustainable livelihoods approach focuses more on capabilities, assets or resources available to cope with vulnerability. Livelihoods comprise of the capabilities, assets and activities required to earn a living. Households derive their livelihoods from a portfolio of both tangible and non-tangible assets. When a hazard takes place, the question is, are resources in place for a household to cope with and recover from the shock in a sustainable manner? The household must have the skills or assets needed to survive negative shocks (UNDP, 2017, DFID, 1999). In addition, DIFD notes that a “livelihood is sustainable when it can cope with or recover from stress and shocks and maintain or enhance its capabilities and assets both now and in future, while not undermining the natural resource base”. According to the SL model, people’s livelihoods are based on five capitals; physical, human, financial, social and natural (Matyas & Pelling, 2012). The different types of assets are shown in Figure 7.



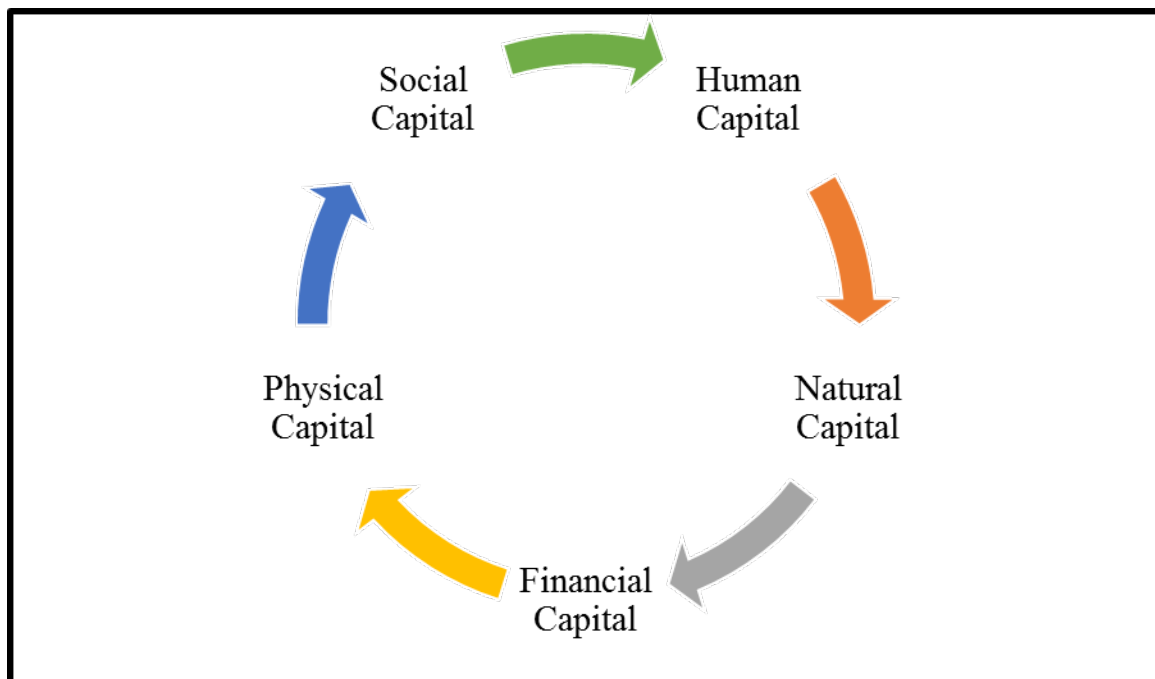


**Figure 7 Sustainable Livelihoods Capitals**

Source: Twigg (2001), Matyas and Pelling (2012), DFID (1999), UNDP (2017)

In line with Ibrahim *et al.*, (2018), the five assets as illustrated in Figure 2.8 above are:

- Physical assets: infrastructure equipment that includes affordable transport, secure shelter, adequate water supplies, reliable sanitation facilities, access to information;
- Financial assets: cash, savings, credit, inflows of money other than earned income (pensions or remittances);
- Natural (environment) Assets: stock of natural resources (land, forests, marine and wild resources, water, productive soils). The natural capital is also about protecting the environment (soil, water) where, for instance, mining activities should use measures that protect the environment so that the negative impacts (soil or water contamination such as mercury effects) are addressed;
- Human assets: knowledge, skills, ability to work, good health;
- Social assets: networks and affiliations.

According to some SL theories, when society or community builds assets, it reduces personal daily vulnerability to impacts so that households can cope or resist. By moving

away from dependency, a number of outcomes can be achieved. Twigg (2001), groups the outcomes into five broad categories, namely:

- More incomes and more sustainable livelihoods;
- Increased wellbeing due to human or financial assets among others;
- Reduced vulnerability to shocks;
- Improved food security;
- More sustainable use of natural resources.

Therefore, household levels of assets play a pivotal role in reducing vulnerability caused by disaster risk impacts (Vatsa, 2004, Skoufias, 2003). According to UNDP (2013), households that are resilient are often identified on the basis of their physical, human, financial, natural and social assets (UNDP, 2013, Twigg 2001, Vatsa 2004, UNDP, 2013). That is, the greater the household asset levels, the greater its capacity to cope with risk, and the lower the level of vulnerability. The less assets the households have the higher their risk and vulnerability levels, and as such they cannot cope with the disaster risks impacts. Poor households have fewer capitals to liquidate in case of a shock. On the other hand, households with abundant capitals can easily convert the financial or physical assets so as to insulate themselves against adverse shocks (FFC & FARNPAN, 2014). Table 3 shows indicators of increasing and decreasing vulnerability. The SL model has been adapted and applied in various contexts. A case in point is the FARNPAN's Household Vulnerability Index (HVI), which operationalises the SL model by assessing household vulnerability based on the five capitals as identified above. The (HVI), is a statistical tool to quantify household vulnerability. The tool comprises 15 indicators of household vulnerability. On the basis of the 15 indicators, also called dimensions, a statistical score is computed for each household and the resultant index – known as the HVI Index – is used to classify households into different levels of vulnerability. The HVI assesses the household's access to (1) natural assets such as land, soil and water; (2) physical assets such as livestock and equipment; (3) financial assets such as savings, salaries, remittances or pensions; (4) human capital assets such as farm labour, gender composition and dependents; and (5) social assets such as information, community support, extended families and formal or informal social welfare support.

Thus, SL theories bring to the fore innovative thinking to disaster and vulnerability analysis. These theories view livelihoods holistically. However, while the SL has been adapted and applied in various contexts (Ncube *et al.*, 2016), its main weakness is that its scope is broad. The biggest challenge associated with the broad scope is the difficulty in identifying the priority needs out of the many that the model brings out.

**Table 3 Indicators of increasing and decreasing vulnerability**

| <b>Type of Asset</b>    | <b>Indicator of Increasing Vulnerability</b>                                                                                                                                                                          | <b>Indicator of Decreasing Vulnerability</b>                                                                                                                                                                               |
|-------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Financial Assets</b> | Withdrawal of savings<br>Rise in indebtedness<br>Rise in unemployment<br>Loans for consumption<br>Default or postponement of loan repayment<br>Dependence on remittances<br>Lack of insurance                         | Sustained level of savings<br>Diversified financial invest<br>Rise in employment<br>Credit for productive asset<br>Loan repayment on schedule<br>Availability of a wide range of financial instruments                     |
| <b>Physical Assets</b>  | Crop failure<br>Soil erosion and degradation of land<br>Damaged and destroyed houses<br>Disruption or closure of business<br>Distress sale of household consumer durables<br>Informal housing<br>Informal settlements | Diversified cropping<br>Soil and water conservation<br><br>Structural reinforcement of houses<br>Business continuity plans<br>Formal housing<br>Increased level of security for house, crops, business and household goods |
| <b>Human Assets</b>     | Illness and loss of health<br>Deaths and disability                                                                                                                                                                   | Good health<br>Physical capacity to work                                                                                                                                                                                   |

|                                         |                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                      |
|-----------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                         | Poor nutrition<br>Withdrawal from schools<br>Primary concern with coping strategy<br>Bonded and child labour                                                                                                  | Availability of nutrition<br>Educational opportunities for children<br>Opportunities for learning skills<br>Independence and self esteem                                                                                                                                                                             |
| <b>Social Assets</b>                    | Discrimination based on race, gender and ethnicity<br>Social disintegration and lack of trust<br>Lack of participation in community organisations<br>Dependence on charity<br>Looting and criminal activities | Relief and assistance based on equity and special needs for different social groups<br>Community solidarity, cohesion, reciprocity and presence of social networks<br>Participation in community initiatives and volunteerism<br>Self-help and mobilisation of community resources<br>Mutual support and cooperation |
| <b>Natural and Environmental Assets</b> | Limited ownership of land<br>Limited ownership of livestock<br>Increase in environmental degradation<br>Limited food resources                                                                                | Land ownership<br>Livestock ownership<br>Food secure                                                                                                                                                                                                                                                                 |

Source: Vatsa (2004), Matyas and Pelling (2012)

## 2.6 VULNERABILITY: A CONCEPTUAL FRAMEWORK

Vulnerability is a multifaceted concept (Rana & Routray, 2018, Baker, 2009, Health Disaster Management, 2002, Style, 2002, Adger, 2004, Baker, 2009, Moret, 2014, Huafeng, 2016). As such, Baker (2009), Moret (2014), viewed the concept of vulnerability as 'taxonomic' and an 'elusive concept'. There are various reasons for concluding that the concept is multifaceted. In the main, it is because the term is used in different research disciplines and therefore open to various interpretations (Alwang *et al.*, 2002, Gilberto, 2006, Hufschmidt, 2011, Kelly & Adger, 2000). As such there is no

consensus on the term vulnerability. In fact, Gilberto (2006) argues that vulnerability has been used in different research disciplines, in ways that are dependent on the research area. These differences in definition of the concept, therefore, justify a multidisciplinary approach to vulnerability (Alwang *et al.*, 2002, Karim, 2017). Also, it is important to note that defining vulnerability encompasses various components. For example, the Inter-American Development Bank (2005), argues that these various dimensions of vulnerability, once integrated should be termed 'global vulnerability' which would assist encapsulate all the different perspectives. However, Hufschmidt (2011), argues that while these various terminologies of vulnerability give perspective in terms of what makes a community vulnerable, they also 'increases the degree of fragmentation and misunderstanding'.

Thus, the term vulnerability has been broadly defined as the degree to which a system is likely to experience harm due to exposure to a hazard or the degree of loss to liability, to injury, and susceptibility of society (Moret, 2014, Alwang *et al.*, 2001, UNISDR, 2009, De Leon, 2006, Gilberto, 2006, Health Disaster Management, 2002, Style, 2002). In the main, the harm amounts to welfare loss. This implies that the risky event must occur in the area, and once it occurs it means households should respond through using their assets and resources to cope with the disaster. Bollin *et al.* (2003), Birkmann (2007) summarise the multi-dimensionality concept of vulnerability and how it has evolved overtime as shown in Figure 8 below.

Originally, vulnerability was viewed as an internal risk factor and these studies show that the concept has evolved and widened over time. First, from being viewed as consisting of internal risk aspects to a multi-dimensional concept. Subsequently, vulnerability was viewed as the likelihood of a household suffering a loss due to disaster events. Then, thirdly, vulnerability was defined as a dual or double structured concept encompassing coping capacity and susceptibility (Birkmann & Wisner, 2006:11). Vulnerability is conceived of as being double structured because it has the external side (risks or shocks stress in the system or that households are faced with) and the internal side (coping with, resisting or recovering from the risks associated). The external side is what De Leon (2006) refers to as 'primary vulnerability' while the internal side is referred to as 'secondary vulnerability'. Lastly, vulnerability has been viewed as a

multidimensional concept that encompasses physical, economic, social, environmental and institutional factors. Vulnerability, in this last conception is multifaceted (Birkmann, 2007, Sutherland *et al.*, 2005) as it encompasses features of susceptibility, exposure, coping capacity and adaptive capacity, including physical, social, economic, environmental and institutional vulnerability components.

Vulnerability is therefore a state of predisposition to harm from exposure to stresses associated with disaster risk as well as incapacity to respond. It is about exposure and sensitivity. It is in this context that Wisner *et al.*, (2003), Balica (2010) and Uitto (1998) define vulnerability as a risky situation that influences capacity of communities to anticipate, cope with or resist and recover from the impact of a disaster. The common thread in all the studies is that vulnerability is about the susceptibility of people and communities exposed to a disaster and their abilities to cope with the damage or loss (Hilhorst & Bankoff, 2004, Baltic, 2012). Thus, households become exposed or susceptible to vulnerability due to their location (areas built on landslides or nearby mines) and cannot cope or recover from circumstances due to limited resources and neither can households respond or adapt to circumstances they find themselves in. In addition, the pre-existing socio economic and environmental factors exacerbate their situation. For example, lack of- or limited social cohesion, limited economic opportunities or income, and disregard or destruction of natural resources due to negative mining activities (which can cause loss of biodiversity and livelihood) result in households being unable to cushion themselves becoming vulnerable to disaster impacts.

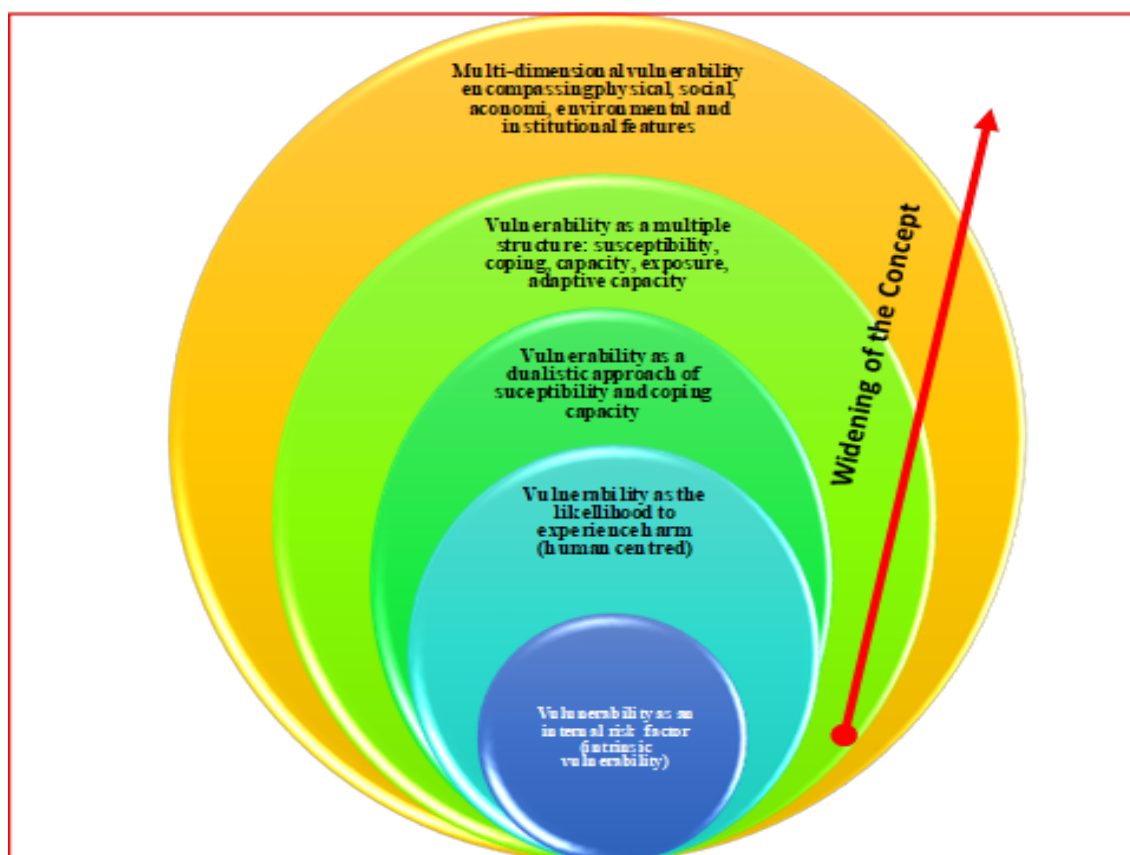


**Figure 6 Widening of the vulnerability concept**

Source: Adapted from Birkmann (2007), Wisner (2006)

In the South African context, the definition of vulnerability has evolved as can be seen in the Disaster Management Act (COGTA, 2002; 2015). It has evolved from being defined as the degree to which an individual, household, or a community may be adversely affected by a disaster to being defined as conditions determined by the socioeconomic and political factors, which result in an increase in the susceptibility of a community to the impact of hazards. Faling (2008), Van Niekerk (2016) note that vulnerability is the extent to which a community or geographical area is likely to be damaged or disrupted by a natural or man-made occurrence as a consequence of the socioeconomic and political conditions. These conditions either increase the suffering caused by the risk or affect the ability of the community to respond and recover from risks. When households lack or have limited physical or material resources, health, skills and labour, savings income, infrastructure, food, housing and capital, they become vulnerable. Vulnerability is even worse for households who reside in areas surrounded by mining activities (Koen

*et al.*, 2017, Coetzee & van Niekerk, 2013, Williams *et al.*, 2018, van Eeden *et al.*, 2009).

Households residing in these areas are vulnerable to, among others; sinkhole formation, waste dumps, contaminated water due to mercury and other harmful substances, as well as to damage to their property or infrastructure. In addition, they are at risk to acid mine drainage, toxic mercury metals, dust and air pollution (Winde & Stoch 2010, Bhebhe *et al.*, 2013, Ngcobo, 2006, Marais *et al.*, 2018, Wollkersdorfer *et al.*, 2011, Van Eeden *et al.*, 2008). Once people lack or have limited resources and are exposed to harm, they are more vulnerable to disasters. In South Africa, vulnerability is therefore closely linked to the history, politics, and the socioeconomic and environmental conditions in which people find themselves. The need for assessment of the vulnerability of critical facilities, social and economic infrastructure, the use of effective early warning systems and the various applications of scientific and technical skills is key in order to reduce disaster risks and vulnerability (Vermaak & van Niekerk, 2014). The National Disaster Management Framework (2005), the White Paper on Local Government (1998) have both emphasised the need for prioritisation of developmental measures that reduce vulnerability levels among households and communities. Generally, it is important to underscore the point that vulnerability is a dynamic concept. To minimise vulnerability, it is important to evaluate the determinants or drivers of vulnerability. Some understanding of the drivers of vulnerability is important for disaster management. The next section presents a conceptual analysis of the determinants of vulnerability.

## **2.7 DETERMINANTS/DRIVERS OF VULNERABILITY**

As the concept itself, the determinants of vulnerability can be traced to a number of disciplines. In this section five main determinants or drivers of vulnerability are discussed and explained. However, it should be noted that what is discussed is not an exhaustive list. The five determinants of vulnerability are exposure, susceptibility and coping capacity; vulnerability determined by household assets and lastly vulnerability determined by the environmental, socioeconomic and political context.



### **2.7.1 Determinants of Vulnerability: Exposure, Susceptibility and Coping Capacity**

Birkmann (2011), Gilberto (2006), Hufschmidt (2011), Palliyaguru (2014), Bhattacharjee and Behera (2018), Sarker (2019) note that vulnerability can be traced to elements of exposure, susceptibility and coping capacity (see Figure 7 below). Exposure is defined as the degree and extent to which a system has been exposed to the risk. As Sarker (2019:1273) notes, exposure “shows the frequency, and extent of loss in terms of livelihood capitals”. Susceptibility, in turn, refers to the degree to which the system has been affected by external events (Gilberto, 2006, Thywissen, 2002). Therefore, vulnerability is defined as a chance that any community can be exposed (De Bustillos *et al.*, 2002, Adepimbe, 2011, Mitchell, 1999, IPCC, 2012). Sarker (2019:12769) notes that vulnerability is characterized by the “susceptibility to be victimized or disrupted by disasters”. Coping capacity refers to the ability to cope with shocks (Birkmann, 2011, Thywissen, 2002, Gilberto, 2006 Hufschmidt, 2011). While various studies on vulnerability have focused on capacity to respond after a disaster has taken place, Birkmann (2011), Thywissen (2002), Gilberto (2006), Hufschmidt (2011), note that capabilities can be reactive (coping) or proactive (dynamically adaptive). That is, coping mechanisms can be applied before a disaster or after a disaster has taken place. Coping capacities are therefore the capacities to ‘live through’ or survive a disaster, and then return back to the pre-disaster situation, or even a better one (Clark-Ginsberg & Hunt, 2013). Coping is a concept that can easily be confused with adaptation. Matyas and Pelling (2012), underscore the point that there is a difference between coping and adaptation strategies. Coping is about utilisation of existing resources, assets, and capitals to confront a perceived risk or respond to the hazardous impacts. Adaptation is about the reorganisation and reprioritisation of resources based on anticipated or experienced dynamism in hazard and risk. This may imply that, coping is about the conversion of savings and productive goods for the fulfilment of basic needs and coping may exhaust resources that could be employed for more strategic adaptation. While adaptation has the potential to reorganise community’s resources and priorities in ways that limit the need for future coping. Both these concepts are useful, yet their differences are often blurred.

Therefore, exposure and susceptibility are conditions for vulnerability in disaster related areas. Simply put, Smit and Wandel (2006) state that vulnerability reflects exposure and

sensitivity to a disaster risk and tests the capability of resilience of households to cope or adapt to the impacts. In the context of the surroundings of mining areas and activities, vulnerability denotes exposure to hazardous events including floods underlain by dolomite that form sinkholes, fires, water pollution, acid mine drainage, the mercury effects of gold mining, mine tailings, open pits and waste dumps (Coetzee & Van Niekerk, 2013, Koen *et al.*, 2017, Utembe *et al.*, 2015, Environmental Law Alliance World Wide, 2010, Hausermann, 2019, Carvallo, 2017, Li, 2018).

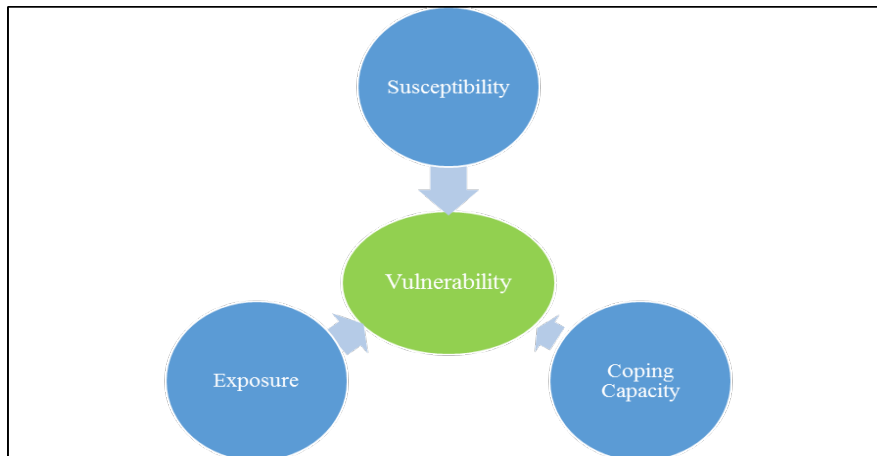


**Figure 7 Vulnerability: Susceptibility, Exposure and Coping Capacity**  
Source: Sarker (2019)

### 2.7.2 Vulnerability Determined: by Household Assets

The degree of vulnerability largely depends on the type of risks as well as household ability to respond to the risky events (Alwang *et al.*, 2001, Modica & Zoholi, 2016). By implication, it means the ability of a household to respond and recover from risk which also depends on household assets (natural, economic, physical, social and human) (Ikegbu & Enyimba, 2020). The Global Assessment Report 2019 is of the view that as households become vulnerable to disaster risks, some become more vulnerable than others, depending on availability of resources that assist them to bounce back to their original position (UNISDR, 2019). Therefore, vulnerability can be defined as ‘processes which increase the susceptibility of an individual or community assets’. In support of the views above, De Leon (2006) argues that a relationship exists between vulnerability and coping capacity and assets, that is, the more assets households have, the less vulnerable they become as assets will increase their capacity to cope with disaster related risks. As such, Vatsa (2004) is of the view that assets are the means of

resistance to the impact of a disaster, and therefore household resilience is closely correlated to asset ownership. Household assets correspond to its poverty level; where poor households would have lower level of assets while moderate and vulnerable non-poor households have increasingly higher levels of assets and they can reprioritise and re-allocate their response to respond to risks accordingly, for instance, using savings or insurance to draw resources. Put differently, Health Disaster Management (2002), Vatsa (2004), Theron (2015), Usamah (2014) argue that the degree of vulnerability depends upon the resilience of the society to that particular risk.

As a result, vulnerability can be viewed as household characteristics in terms of their capacity to anticipate, cope with, resist and recover from impact of disaster risks (Raheem *et al.*, 2013). This implies that, the more households are resilient to the disaster risk impacts, the less vulnerable they become. Likewise, the less resilient households are to the disaster risk impacts, the more vulnerable they become. That is the same as equating the concept of resilience with assets that households have; that is the more assets households have, the less vulnerable they become and the less assets households have, the more vulnerable they become. Resilience is, therefore, inversely related to vulnerability (see Figure 10). At point A in Figure 10, higher vulnerability is associated with lower resilience, while the opposite is true at point B.



**Figure 10 The relationship between Vulnerability and Resilience**

Source: Style (2002)

### **2.7.3. Vulnerability Determined: Environmental, Socioeconomic and Political Contexts**

According to Baas *et al.*, (2008), vulnerability relates to the conditions that determine the socioeconomic and environmental circumstances, which in turn, increase exposure of households to disaster risks impact. That is, prevailing socioeconomic and environmental conditions result in susceptibility of households to the impact of disaster risks. Some aspects of vulnerability arise from, among other things, the physical, social, economic, environmental, political and institutional factors (Thywissen, 2002, UNISDR, 2009, Kohn, 2014). The UN defines vulnerability as “the conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards” (UN/ISDR, 2004). In fact, this aspect of vulnerability is what Gaillard and Kelman (2011), Hufschmidt (2011) refer to as the human ecologist and structural paradigms. In the former, focus is on measures that need to be in place to reduce the disaster risk caused by human activities. In the latter, the socioeconomic, environmental and political contextual factors or conditions are also the causes of the losses or injuries that occur. This is because the physical, social, economic, and environmental factors tend to increase the susceptibility of a community to the impacts of hazards (Hufschmidt, 2011, Coetzee & van Niekerk, 2013, Utembe *et al.*, 2015, Cronje *et al.*, 2013, Koen *et al.*, 2017). This implies that the determinants of vulnerability to disaster risks can be traced to a combination of the socioeconomic, physical, environmental and political circumstances, as well as the dynamic pressures, such as population density, inappropriate land use, poverty, social injustices and unsafe working and environmental conditions acting as catalysts (Van Huyssteen *et al.*, 2012, Melore & Nel, 2020, Williams *et al.*, 2018, Pokorny *et al.*, 2019, Marais & Nel, 2016, Nelson, 2018). Due to the different socioeconomic and environmental factors, vulnerability will always vary among households.

The key to understanding vulnerability lies in the interaction between the socioeconomic and environmental factors within the society. The exposure of society to disaster risks triggers vulnerability of households by interfacing with the underlying socioeconomic, environmental, demographic and political aspects (Cardona, 2012:70, Van Huyssteen *et al.*, 2013:5, Beccari, 2016:5).

Understanding socioeconomic and environmental circumstances by disaster practitioners may help to better target interventions and effectively implement disaster risk strategies. Fang *et al.*, (2016), Costella and Oyadiya (2014), Abunyewah *et al.*, (2018) state that analysing vulnerability at the household level can assist in identifying the threats that households face and the potential coping and adaptation approaches. The next section discusses household vulnerability and vulnerability comparisons.

## **2.8 HOUSEHOLD VULNERABILITY: COMPARABILITY ANALYSIS**

The extended concept of household vulnerability can be defined as a household being vulnerable to a loss or future loss of welfare below the socially accepted norms as caused by risky events (Alwang *et al.*, 2001). Within a household there are groups that become highly vulnerable compared to others due to limited access to resources that could cushion them against the disaster risks (Morrow, 1999, Vink & Takeuchi, 2013, Usamah, 2014, Costella & Oyadiya, 2014). In the main, household groups that are more vulnerable are the poor, women, children, squatters or informal settlement dwellers, the elderly, women and child headed households, people with disabilities, workers in the informal sector, migrants, tenant farmers, tenants and homeless people (Mohapatra, 2012:2002). These group of households, and members of households, often face difficulties in accessing the resources they require to respond to the disaster events and as such become vulnerable. Therefore, vulnerability to disaster risks is context specific, and requires thorough analysis of households residing in any particular area (Abunyewah *et al.*, 2018).

Further, households become vulnerable due to the various circumstances. Firstly, these include households' health status, access to resources and environmental conditions (Usamah, 2014, Alwang *et al.*, 2001, IRS, 2012, Vatsa, 2014, Costella & Oyadiya, 2014). Households in good health tend to be less vulnerable to disaster risks than those households who are not. Access to resources plays a pivotal role towards lessening vulnerability. Households with limited access to resources are more vulnerable compared to households with resources, as the latter can reprioritise their resources and lessen the impact of a disaster. Similarly, negative environmental conditions

associated with mining activities such as the contamination of soil and water by mercury particles exacerbate household vulnerability (Van Eeden *et al.*, 2009, Liefferink & Van Eeden, 2010, Bhebhe *et al.*, 2013, Ackerman *et al.*, 2018, Carvalho, 2017). Other environmental risks that contribute to vulnerability include veld fires, floods, and waste dumps due to mining activities (Coetzee & van Niekerk, 2013, Katpatal & Patil, 2010). Households that reside in flood prone areas are also vulnerable to landslides as well as mining activities in the form of mine tails or dam tailings. Furthermore, households, especially the poor, become vulnerable due to non-existent or limited social capital whilst they are also politically disenfranchised and therefore do not receive social services or social relief after a disaster takes place.

Abunyewah *et al.*, (2018), Williams *et al.*, (2018), observed that the urban poor who reside in informal settlements are more vulnerable as they reside in areas regarded as hotspots for disaster risks, such as floods and fires. Informal settlements are more vulnerable due to poor urban planning and failure to follow building standard codes. As such, informal areas have inadequate access to basic services such as water, electricity and sanitation. Households who reside in the informal settlements have low levels of income, and face high unemployment and low levels of education, which results in low skills levels in these areas.

On top of the daily urban challenges of unemployment and poverty, informal settlements have lower access to services compared to the formal counterparts. Without access to basic services household abilities to withstand disaster risk impacts are limited (Coetzee & van Niekerk, 2013, Marais *et al.*, 2018, Owen *et al.*, 2019, French *et al.*, 2017, Koen *et al.*, 2017). Winde and Stoch (2010), Coetzee and Van Niekerk (2013), Van Eeden *et al.*, (2009), Marais *et al.*, (2018) argue that the increase in urban growth has resulted in shacks being built on abandoned mining land and that exposes households to risks such as dust and mine tailings.

As alluded to above, mining activities result in, among others, air and waste pollution, acid mine drainage which contaminates water, dam/mine tailings, dust, mercury contamination on land, soil erosion and deforestation, which all affect individual livelihoods (Roopnarine, 2002, Utembe *et al.*, 2015, Van Eeden *et al.*, 2009, Friends of

the Earth, 2007, Carvallo, 2017). The disaster in Brazil alluded to above, which was caused by the collapse of a tailings dam affected water and soil ecosystems besides causing loss of lives (Heller 2019, Garcia *et al.*, 2017, Owen *et al.*, 2019). The World Resource Institute (2003), argue that in mining activities, the stakes are high in areas where communities and environmental resources are at risk. The report further states that while mining boosts economies and is an important source of income, those who suffer the most from mining related activities are the impoverished communities with low levels of human capital (educational attainment), income, limited access to basic services and information, and facing high poverty levels and unemployment.

## **2.9 CONCLUSION**

In Chapter 2 the conceptual and theoretical frameworks that underpin disasters, disaster risks, vulnerability were discussed. The chapter assessed how these concepts relate to households, especially those in environmentally brittle mining risk area and their surroundings. The literature on concepts and theoretical frameworks revealed the following; Firstly, that there is no universal definition of the terms disasters, disaster risks and vulnerability, as they are discipline dependent. The literature showed that, regardless which discipline was considered, there was only one conclusion; that disasters, disaster risks and vulnerability affect the collective rather than the individual, and that disaster situations denoted that there was a loss that occurred which exceeded the capacity of household to withstand the disaster impacts. Secondly, that disasters are as a result of a hazard and exposure which makes households vulnerable to the damage or loss of lives, livelihoods, and socioeconomic and environmental systems. Thirdly, disasters can either be human induced or natural hazards, or a combination thereof. Lastly, the literature revealed that disasters and disasters risks are complex and both the cause and consequence of vulnerabilities of households.

There are various reasons behind households being vulnerable to disaster risks. Households become exposed or susceptible to vulnerability due to their location, for instance when their settlements are built on landslides or in areas surrounded by mines which have negative environmental effects. Often in such cases, households can neither cope or recover from disruptions nor respond or adapt to circumstances they

find themselves in due to limited resources. In addition, the pre-existing socio economic and environmental factors exacerbate their situation. For example, limited social cohesion and economic opportunities and disregard or destruction of natural resources result in households being unable to cushion themselves and being vulnerable when disaster impacts strike.

Informal sector dwellers according to literature find themselves in vulnerable areas not because of choice, but because of their socioeconomic, environmental and political circumstances. In many cases they are faced with the effects of negative mining activities from mining sites close by which pollute the water and among other things cause acid mine drainage which affects lives and livelihoods of the community. These impacts are felt over and above the socioeconomic upheavals of the life in the township, which include lack of employment, high poverty levels, lack of skills and education, limited income opportunities and limited basic services. These factors exacerbate conditions, more so for the informal households than their counterparts who reside in the formal areas.

The chapter established, that the best approach for addressing these complexities is through an inter- and multi-disciplinary approach so as to ensure integration of methods and analysis from different disciplines to best inform solutions. There chapter surveyed explanatory models of vulnerability, including the PAR, Access, SL and the HVI models. It was shown that the PAR and access models of vulnerability provide a framework for analysing livelihoods and different circumstances that result in vulnerability, while the SL model assessed household vulnerability through the use of five capitals and if households lacked or had limited access to these capitals they became vulnerable.

Households that are poor and live in informal areas are prone to vulnerabilities by virtue of their economic circumstances as they lack assets or resources to minimise the impacts of disasters. Literature is also clear that addressing vulnerability should not be one-size-fits-all, but solutions should be tailored to fit household circumstances, which translates into effective and efficient use of resources. Further, a comparative approach addresses the different household socioeconomic circumstances.



Lastly, the formative discussion on the theories of disasters and vulnerability in this chapter had revealed that the two concepts are increasingly being approached from an inter- and multi-disciplinary perspective. Such an approach has not only enhanced our understanding of disasters and vulnerability but has also enhanced policies and interventions designed to ameliorate the impact of disasters and minimise the vulnerability of households. The different theories reviewed in this chapter classify disasters into different categories. Classifying disasters according to source is key to identifying suitable mitigation and adaptation strategies. A proper diagnosis of the causes and consequences of disasters ensures that appropriate mitigation and adaptation strategies are deployed.

Chapter 3, which follows, assesses the empirical evidence and practical application of the concepts of disasters, disaster risks and vulnerability to households and their comparability.

## **CHAPTER 3**

### **A REVIEW OF EMPIRICAL LITERATURE: DISASTER (MINING) RISKS AND VULNERABILITY**

#### **ON**

The present chapter reviews empirical literature on disaster risks and vulnerability of households in mining communities. This literature review builds on the concepts and theories discussed in the preceding chapter. This chapter places particular emphasis on past empirical and practical methods used to evaluate disaster, disaster risks, and household vulnerability in communities surrounding mining areas. For the purposes of this study, mining communities represents a community that has been affected by nearby mining operations activities and often these mining communities are in remote areas where there are few opportunities for diversification (Veiga, 2001, Raheem *et al.*, 2013, Van Eeden & Khaba, 2016, Koen *et al.*, 2017). The Global Assessment Report 2019 refers to these negative mining effects or hazards as: ‘...other hazards less familiar as they were not part of the Hyogo Framework for Action. However, they are part of the Sendai Framework which (include chemical/ industrial risks such as mining)’. As such, it becomes imperative that research is conducted on these new exposures or hazards so as to have effective measures to reduce the disaster risks impacts.

Since this study seeks to compare the vulnerability of informal and formal sector households, literature on comparative analysis of households was reviewed. The literature reviewed was inherently multidisciplinary as the present study assumes a multidisciplinary approach. The literature reviewed pays particular attention to how past studies quantified vulnerability and how the case study approach was used. The quantification of vulnerability due to disaster related impacts is not a one-size-fits-all because of the multidimensional nature of vulnerability (as highlighted in Chapter 2).

Many vulnerability studies are based on the case study approach. The use of case studies gives the opportunity to explore vulnerability through the lens of the unit of

analysis; in this case the household (UNISDR, 2013). It further offers a chance to identify lessons and similarities between vulnerable households themselves. In terms of analysis, studies on vulnerability adopt a combination of qualitative and quantitative techniques (Ncube *et al.*, 2016, Becari, 2014). It is in this context that the Global Assessment Report (2019) states the necessity of measuring vulnerability. One of the measures that have been used to quantify vulnerability are indices. Indices are used to capture reality better and enable disaster practitioners to plan better (Inter-American Development Bank, 2005, Yoon, 2012). Indices are critical in vulnerability assessment as they easily capture the impact of disasters on socioeconomic and environmental variables in a more precise and succinct manner (Islam *et al.*, 2012, Yoon, 2012). As such, various indices will be explored in this chapter, assessing them for their quantification of vulnerability, with a view to identifying an index to be adopted in this study.

## **3.2 QUANTIFICATION OF DISASTER RISKS**

### **3.2.1 Disaster Risk Index (DRI)**

Empirical studies on the impact of risks often begin with a quantification of disaster risks. First, literature tends to operationalise the concept of disaster risk through an index, that is, the disaster risk index. For example, De Leon (2006), Islam *et al.*, (2012), Xiaoyan and Xiaofei (2012) defined the DRI as simply the sum of risk and vulnerability indices. In essence, the DRI considers the qualitative and quantitative aspects of vulnerability, including the socioeconomic and environmental circumstances of the community in question. The DRI is an important tool used to gain insights on who is vulnerable among social groups and the causes of such vulnerability (Ncube *et al.*, 2016, Islam *et al.*, 2012). In addition, it assesses the impact and likely consequences of disaster risks. In certain situations, the index has been used as an early warning mechanism, thus assisting disaster practitioners to plan and prepare for possible disaster events (Islam *et al.*, 2012).

In Bangladesh, for instance, the DRI has been used to measure the impact of disaster risks (Islam *et al.*, 2012). The DRI was computed using historic and survey data. Disasters risks identified in the study using the DRI included floods, cyclones, rainfall, water logging, hailstorms, tornadoes, droughts, thunderstorms, epidemics, salinity,

erosion and arsenic. Results of the DRI application in Bangladesh indicated that disaster risks are caused by, among others, geographical factors such as households residing in areas that are near riverbanks. In addition, many households in Bangladesh that were vulnerable had poor housing structures, were dependent on state resources and lacked basic facilities. In a nutshell, households in Bangladesh were vulnerable to disaster events due to their weak socioeconomic and environmental conditions. Thus, socioeconomic and environmental conditions of households play a critical role in vulnerability and are key determinants of one's vulnerability status. The advantage of using DRI is that it indicates risks that occur at a particular time including also measuring and comparing levels of vulnerability or susceptibility between communities or among countries. However, its drawback is its failure to aggregate disaster risks, whilst the indicators are also subjective (Peduzi *et al.*, 2009, Balica, 2012). In the present study, the variables mentioned above were incorporated into the questionnaire administered to households sampled.

Due to the multifaceted nature of vulnerability as discussed in Chapter 2, there is not a standard measure of vulnerability. The next section discusses empirical studies on vulnerability and its measurement.

### **3.3 APPROACHES TO VULNERABILITY ASSESSMENT**

#### **3.3.1 Vulnerability Index (VI)**

Considering that most of the vulnerability indicators are subjective, there is always a need to continuously subject them to empirical scrutiny to ensure that their validity and robustness is guaranteed. As elaborated on in Chapter 2, vulnerability is a multi-dimensional concept and as such, various analytical methods have been used to analyse and quantify it (De Leon, 2006, Balica, 2012). These include the vulnerability index (VI), the most common tool used to capture the multidimensional and multidisciplinary nature of vulnerability. Although there is no standardised way to measure vulnerability, in many instances the measurement often depends on the risk that occurs, how often the risk occurs, the magnitude of the risk and its complexity (Balica, 2012, Peduzi *et al.*, 2009). In many instances, vulnerability indices take into account the social, economic and environmental variables that make households or individuals vulnerable (Balica, 2012, Islam *et al.*, 2012).

According to Ismal *et al.*, (2012), the VI takes into account variables such as unemployment status, number of households, literacy rates, population density, average income per household, access to basic services, warning systems, knowledge base on disasters and geographic factors, like access to paved roads and proximity to rivers and disaster quarters. Advantages of using the VI include that it comprehensively captures dimensions of vulnerability. It is simple and easy to use. The VI, not only assists in identifying the most vulnerable populations, but it also identifies the exact dimensions that cause people to be vulnerable (Balica, 2012, Islam *et al.*, 2012, De Leon, 2006). Thus, the index value for each indicator can assist in identifying the underlying factors responsible for an increase in vulnerability as well as the relevant course of action to be taken. These variables were taken into account in the study questionnaire, as elaborated in chapter 5 of the study.

### **3.3.2 Social Vulnerability Index (SVI)**

Another aspect to measuring vulnerability, is the social dimension of vulnerability, called Social Vulnerability Index (SVI), which refers to the socioeconomic and demographic factors that affect the resilience of communities (Flanagan *et al.*, 2011, Yoon, 2012, Nguyen *et al.*, 2017). The SVI spatially identifies socially vulnerable populations, and it assists in comprehensively understanding how disasters affect communities in their respective households. The SVI is made up of four variables, namely (i) Household socioeconomic status (such as income, poverty, employment and education), (ii) Household composition and disability status (for example, age, single parenting and disability variables), (iii) Minority status or Language (for example, race, ethnicity and language) and (iv) Housing and transportation (for example, housing structure, crowding and vehicle access) (Yoon, 2012, De Leon, 2006, Flanagan *et al.*, 2011, Nnadi, *et al.*, 2019). The main challenge often encountered with the SVI, is that one must allocate weights to each variable. Weights are often given arbitrarily or on the basis of experience. The SVI focuses on describing characteristics of communities and gauging whether they are prepared for, can respond to, or recover from disasters. When a household has less social capital, the household becomes socially vulnerable. Different communities will experience the same disaster differently due to differences in social capital.

Empirical works that adopts the SVI approach is vast. For instance, an assessment of the vulnerability of households in the Villa Canales municipality in Guatemala (De Leon, 2006) used the SVI method. Based on survey data from households, this study took into account four vulnerability factors; physical, social, economic and environmental dimensions (see Figure 11 below). These factors are interrelated and interdependent as depicted by the venn diagram below. Variables used for calculating vulnerability under each factor are indicated in Table 4.

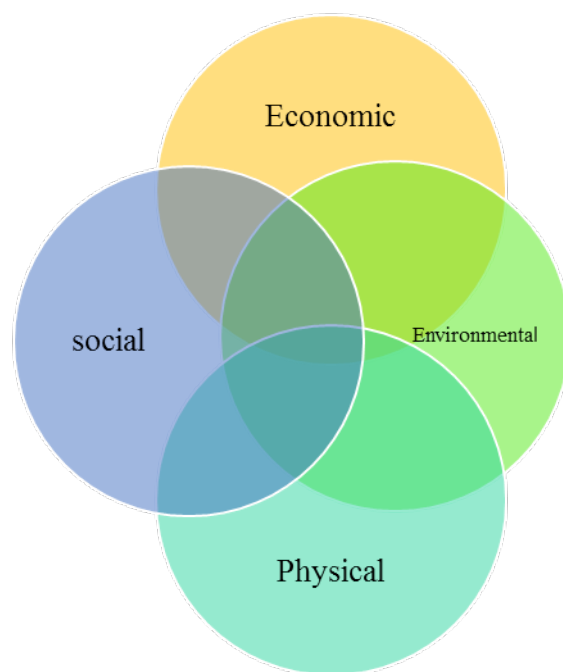


**Figure 8 Factors influencing vulnerability**

Source: UNISDR (2004)

**Table 4 Indicators for assessing vulnerability**

| Economic                                                                     | Social                                                                                              | Physical                                                                                       | Environmental                                  |
|------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|------------------------------------------------|
| Local resource base<br>Diversification<br>Small enterprises<br>Accessibility | Level of poverty<br>Degree of illiteracy<br>Attitude<br>Decentralization<br>Community participation | Population density<br>Demographic pressure<br>Insecure settlements<br>Access to basic services | Forest area<br>Degraded area<br>Over-used area |

Source: De Leon (2006), See also Yoon (2012), Flanagan *et al.*, (2011) and Nnadi *et al.*, (2019)

Secondary data was used to supplement primary information in the Guatemala study. Each variable was accorded a score between zero and 10, depending on the depth of vulnerability. A score close to zero signified low vulnerability, while a score close to 10 indicated high vulnerability. The scores were then added up to produce a composite social vulnerability index score for each county. The scores were scaled up so that positive values indicated higher values of vulnerability while the negative ones showed lower vulnerability. The results of the study indicated that the poorest areas of the municipality and informal sectors, were more vulnerability to risks. Household vulnerability was influenced by economic, social, physical and environmental factors. The present study will follow the SVI approach closely in terms of variables used as elaborated in Chapters 5, 6 and 7 later.

### **3.3.3 Climate Vulnerability Index (CVI)**

Pandey and Jha (2011) assessed the climate change vulnerability of two communities in India using the climate vulnerability index (CVI). The CVI is useful in assessing and monitoring vulnerability under stress conditions or in evaluating effectiveness of programmes. The index consisted of variables describing three aspects of vulnerability; exposure, sensitivity and adaptive capability. Exposure was defined by natural disaster and climate variability; sensitivity was defined by health, food and water; while adaptive capability was depicted by the socioeconomic and demographic profiles, livelihood strategies and social networks. A household survey of 50 randomly selected households was conducted in the two regions of India to obtain data to populate the CVI. The data was aggregated to generate a composite index. The vulnerability status ranged from high (0) to low (1) vulnerability. The index enabled a comparative analysis of community vulnerabilities. The findings of the study showed that households that had poor livelihood strategies, poor food nutrition and health, as well as limited and polluted water resources, were more vulnerable compared to their counterparts with abundant food, better health, and water resources. The study therefore confirmed that vulnerability levels of households' matter and differ. The variables used in the study

informed variables captured during the data collection through the survey questionnaire in the present study.

### **3.3.4 Multidimensional Vulnerability Index: (MVI)**

In a study of disaster vulnerability in Pakistan, Rana and Routray (2018), developed a multidimensional model of vulnerability and then used the model to quantify vulnerability. Indices were developed for the five dimensions of vulnerability (social, economic, physical/infrastructural, institutional and attitudinal). Three study sites were selected in Pakistan. The study sites were purposively selected with one being susceptible to riverine floods, while the other two were prone to flash floods. A household survey was used to gather information from a sample of 210 households. Social vulnerability, economic vulnerability, physical/ infrastructure vulnerability, institutional vulnerability and attitudinal vulnerability indices were all calculated resulting in a multidimensional vulnerability index. Values closer to 0 signified low vulnerability and those close to 1 denoted high vulnerability. In terms of the multidimensional vulnerability index, 12% of households were highly vulnerable, of which two were urban centres and nine in rural areas. On average there were slight variations in social, economic and physical/infrastructural vulnerability between the three study sites. Variations were more pronounced in attitudinal and institutional vulnerabilities, which suggested that poor perceptions by residents on disaster related incidences as well as limited knowledge and awareness by the disaster risk practitioners in the area were key in explaining vulnerability. The indices used in this study, were incorporated in the present study as discussed in Chapter 6.

While measuring vulnerability through applying indices provided insights into vulnerable households and the causes thereof, Lu *et al.*, (2004) noted limitations with the traditional index approaches to measuring vulnerability. The main challenge with using indices is the weights attached to each variable. In most instances, weights have been subjectively selected resulting in biased vulnerability estimates. Lu *et al.*, (2004) thus proposed the use of the Data Envelopment Analysis (DEA) approach to analyse relative severity of disasters. The DEA is a non-parametric technique that is designed to measure the relative vulnerability of different decision-making units (see Charnes and



Rhodes, 1978). The DEA approach was applied in China (Lu *et al.*, 2004). The study found that vulnerability to natural disasters has a close relationship with the physical and social environments of the region. Furthermore, there was a negative correlation between the level of regional vulnerability and the level of regional economic development. In other words, the more economically developed a region is, the lower its vulnerability. The advantage of the DEA technique is that it does not require weights to be attached to inputs and outputs in the evaluation of vulnerability. The variables indicated in this application have been taken into account in crafting the questionnaire in the present study. The subsection below reviews literature on household vulnerability, including households residing in mining areas.

### **3.4 HOUSEHOLD AND COMMUNITY VULNERABILITY TO DISASTER RISKS**

Household vulnerability is influenced by a number of variables (Birkmann 2007, Costella & Oyadiya, 2014, Abunyewah *et al.*, 2018, Usamah, 2014, Alwang *et al.*, 2001, Vatsa, 2004, Ackerman, 2018, Carvallo, 2017, Coetzee & Van Niekerk, 2013, Marais *et al.*, 2018). Takashi (2010) analysed household vulnerability in Northern Punjab and Southern Punjab regions in Pakistan using a two period panel data covering 1 600 households. The results of the study suggested that access to land was an effective factor in mitigating the ill effects of various types of disaster risks. In other words, land ownership has a bearing on household vulnerability to disaster risks. Further, it was found that marginalised households such as those headed by widows without sons, women with husbands with disabilities, divorced or unmarried women, people with disabilities, orphans and the elderly were more vulnerable to disaster impacts than any other household group (Takashi, 2010, French *et al.*, 2017, UNSDIR, 2019, Costella & Oyadiya, 2014, Vink & Takeuchi, 2013). Like Takashi (2010), Kurosaki *et al.*, (2011) assessed household vulnerability to natural disasters in Pakistan. The study was based on a survey of households affected by floods. The study also assessed the effects of aid on household vulnerability and the impact of socioeconomic circumstances on household recovery from disaster risks (Kurosaki *et al.*, 2011).

Results from the study suggested that households were more vulnerable to floods if they lacked assets such as housing, land and livestock, among other assets. In other words, households with a lower asset base (crops, houses, land and livestock) were hit

hardest by flooding and had more difficulty in recovering – suggesting that vulnerable households need more support.

The studies reviewed thus far share some commonalities, such as that marginalised households suffer most from disaster related risks and are more vulnerable when compared to other households that are not marginalised. In addition, the socioeconomic and geographic context that households found themselves in contributed to their vulnerability. For example, households located in slums tended to be more vulnerable than those households in non-slum areas.

Chatterjee (2010), used the case study approach in a study in Mumbai to assess vulnerability to disaster risks of marginalised slum dwellers as well as investigate measures that should be adopted by households in those informal settlements/slums to adapt to disasters. The results of the study indicated that capacity to respond is not equally distributed among slum dwellers due to the underlying socio-cultural divisions as well as emerging economic and political constraints. Further, low-income populations living in informal settlements do not migrate when disaster hits. Instead, households develop resilience by adapting to the risks and incorporate methods that will assist in minimising the impacts. The present study uses the case study approach in order to get deeper insights into, among other factors, the determinants of household vulnerability and reasons for variation in vulnerability across households. Williams *et al.*, (2018), evaluated the association of urbanisation and vulnerability to climate change. A case study of an informal settlement in Durban, KwaZulu Natal, was adopted. The researchers found that urbanisation has compounded the vulnerability of the urban poor in the Quarry Road West informal settlement, an urban poor community in the marginal areas of Durban. It was further noted that climate change has increased the frequency, intensity and predictability of hazards in the area. Urban areas were now vulnerable to storms, floods, drought and rising sea levels, which exacerbated existing high levels of poverty and unemployment in the informal settlement which is located in narrow floodplain areas which are prone to floods and disasters. This study underscores the point that a community is vulnerable because it lacks access to livelihood assets – which include social assets (for example, social networks, participation and trust), human assets (such as preparedness through knowledge and education), political assets (for example, transparency and trust in political issues, where protest action and

corruption are indicators for trust and transparency), financial assets (including financial security and disaster funds) and environmental assets (such as awareness of ecosystem services, management strategies and planning processes (Williams *et al.*, 2018, Morrin *et al.*, 2016, Abunyewah *et al.*, 2018, Pokorny *et al.*, 2019, Matyas & Pelling, 2012, FFC & FARNPAN, 2014, UNDP, 2017).

Napier and Rubin (2002), examined disaster risks affecting informal settlements in South Africa. Disaster risks investigated included floods, shack fires and evictions. The paper adopted a case study of informal settlements in the Eastern and Western Cape provinces. Napier and Rubin (2002), found that informal and traditional settlements were vulnerable to natural disasters such as floods, famine, fires, windstorms and epidemics. A report by Aurecon for the Western Cape Department of Local Government and Housing on the informal settlement vulnerability index supported findings by Napier and Rubin (2002) as it identified risk indicators in informal settlements as density, access to basic services (water, electricity, sanitation services) and health conditions. Major risks to disasters in informal areas were fire and floods (Napier & Rubin, 2002). The study noted that, although early warning systems exist, they did not work due to the systems being vandalised. In addition, residents in informal settlements refused to move when disasters struck, and municipalities were slow to respond to disaster events. There was lack of preparedness in terms of mitigation and prevention strategies on the part of local governments. The household variables mentioned in this study were used as variables in the construction of the present study's questionnaire; the subsequent results are discussed in Chapter 6.

Vermaak and van Niekerk (2004), explored and described numerous mechanisms that could be used to reduce disaster risks and vulnerability caused by the 2000 floods in the Limpopo province. In this study as well, interviews were conducted with residents of informal settlements. The results showed that vulnerability was due to the following factors: damage to infrastructure, loss of crops and livestock, health related challenges, lack of savings, loss of income and labour, and food price increases. Some of the lessons that could be drawn from this study include the importance of indigenous knowledge in risk reduction initiatives. Vulnerability was minimised through applying crop rotation, use of sandbags to stop water speed as well as the planting of trees and grass to protect topsoil, among other things. The lessons learnt in this study were key in

shaping the methodology of the present study and in relation to recommendations presented here.

Where the focus is on communities living near mining operations, most studies point to the negative effects of mining activities on the environment and the socioeconomic wellbeing of the households and communities. In a study of the impact of mining activities on the environment in Guyana, South America, Roopnarine (2002) found out that mining activities drive waste pollution, river contamination, soil erosion, deforestation and destruction of wildlife. Roopnarine (2002), further argues that despite measures being put in place to prevent or reduce these impacts, they have been weak, hence the mining disasters that damage the environment. Similarly, in Indonesia, Limbong *et al.*, (2003) found that mining activities released mercury with dire consequences on the immediate environment, livelihood structures and the wellbeing of households. They underscored the negative environmental impacts of gold mining activities, with some of the negative impacts being attributed to the disregard of safety measures, weak regulations as well as lack of skills. Van Eeden *et al.*, (2009) further attest to arguments above that in the West Rand community, non-compliance with rehabilitation of mine regulations because of organisational failure has led to tailings. Another key factor underscored by Van Eeden *et al.*, (2009) was the closure of mines in the West and Far East Rand area. The closure of the mines had negative effects on the surrounding communities. Many jobs were lost because of mining closures. Informal settlements mushroomed and were often located in areas not fit for human habitation. As such, the informal settlement dwellers used contaminated underground water for their livelihood (water and agricultural activities), posing health related impacts for both communities and animals. The challenge facing these communities was further compounded by day-to-day challenges such as poverty and limited access to basic services in these areas (see also Koen *et al.*, 2017, Ackerman *et al.*, 2018).

Hynes (1997), corroborates the above arguments on lack of safety measures and further emphasises that mining disasters occur because of organisational failures, especially the total disregard of warning and safety measures. WestRay coal mine in the USA was cited as an example where mining disasters in the form of dust, mine cave-ins and explosions occurred because of internal failures and non-compliance with safety measures or processes.

In China, Li (2018) assessed water challenges resulting from mining activities. The results of the study found that mining activities negatively affected the quantity and quality of surface and groundwater in mining areas. The quantity of water supplied to communities was reduced due to higher consumption from mining activities, while the quality declined due to pollution from mercury deposited in water. The study also found that these challenges never ceased with the closure of mines as groundwater continued to be contaminated, while open pits, mine tailings and waste dumps continued to be features of the area. Guerreiro (2007), reported similar findings for mining activities in Spain and observed that mine effluent discharged into rivers resulted in acid mine drainage, which in turn damaged agricultural products and affected livelihoods in nearby communities. The water pollution affected water supply and caused illness, particularly respiratory illnesses, to communities.

In the Philippines, Lindon *et al.*, (2014) studied mining activities and their impact on humans, economic and environmental development. The study found that mining activities have negative impacts on people and economic development. The negative impacts were related to environmental risks that these mines pose such as health hazards, loss of lives and impact on livelihoods (agriculture, water and trading). The environmental risks were primarily due to mine tailings and water pollution arising from mercury effects and dust. In addition, the closure of mines had negative impacts on the community surrounding mines.

Hilson (2002) reported on the impacts of large scale mining in Papua New Guinea and noted that large scale mining caused damage to landscapes and the contamination of soils by metals which affected agricultural activities and caused health related issues in the community. Further, mining activities also resulted in displacement of communities, spread of diseases and poverty. Hausermann (2019) evaluated the impact of Ghana's Offin river gold mining activities on the surrounding community. The findings of the study indicated that mining activities in the area disrupted agriculture systems as land was converted to mining and water systems. Respiratory diseases were common, caused the release of mercury particles. Other negative effects in Ghana were the collection of stagnant water in abandoned mines, which became the breeding ground for mosquitoes and predisposed communities to malaria. The collapse of the Vale tailings dam in Brazil recently (Heller, 2019), which resulted in loss of lives and

livelihood is another example of a mining disaster. The collapse resulted in degradation of soils, deterioration in water quality and ill health in surrounding communities. Other literature sources that specifically look at the impact of mining activities are summarised in Table 5.

**Table 5 Summary of mining activity impact studies**

| Study                                | Country     | Mining Activity/<br>Mining problem                    |                                                                                                                                       | Impact                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|--------------------------------------|-------------|-------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Antoszczy szyn and Michalska (2016)  | Poland      | Coal mining- Mercury contained in the waste mining    | Assessed the potential risk of environmental contamination by mercury contained in Polish coal mining waste                           | Has led to a number of facilities in the form of structurally and age-varied landfills, heaps and mining waste dumps. Health effects of mercury poisoning include irritability, nervousness or excitability, insomnia, dysarthria (motor speech disorder), incoordination, and hallucinations                                                                                                                                                                                                                                                       |
| Basu <i>et al.</i> , (2015)          | Ghana       | Gold-artisanal and small-scale gold mining            | Integrated Assessment of Artisanal and Small-Scale Gold Mining in Ghana                                                               | Artisanal and small-scale miners and surrounding communities were relatively highly exposed to mercury and other heavy metals, occupational injuries and noise pollution                                                                                                                                                                                                                                                                                                                                                                            |
| Leju <i>et al.</i> , (2019)          | South Sudan | Gold- Large and artisanal and small-scale gold mining | Assessed the Environmental Impacts of Gold Mining in Mining Communities in Gorom Village, Rejaf County, Republic of South Sudan Water | Mining activities, particularly from illegal small-scale mining deplete natural resources such as the soil, water, the landscape, biodiversity and the ecosystem. Land around the vicinity of mines has been degraded and vulnerable to severe erosion and loss of viability for agricultural purposes. Illegal small-scale mining has destroyed some important soil organisms and disrupted stable soil aggregates depriving the soil of organic matter and devoid of macronutrients and soil fertility necessary for plant growth and production. |
| Baraka Muvuka and Muriel Jean Harris | Ghana       | Gold                                                  | Assessment of the Impacts of Gold Mining on Women's Health and Quality of Life in Ashanti Region, Ghana                               | Mineworkers and residents of mining communities were exposed to high concentrations of toxic metals (for example mercury, lead, arsenic) in water, food, air, and soil. Although the mining industry provided indirect socioeconomic benefits to women in particular, it was associated with environmental degradation, arrange of health                                                                                                                                                                                                           |

|                              |                    |       |                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|------------------------------|--------------------|-------|-----------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (2019)                       |                    |       |                                                                             | issues, lack of access to farmlands, and limited sustainable income-generating activities for women, all of which negative influenced their quality of life.                                                                                                                                                                                                                                                                                                                                                                          |
| Osei-Yeboah, (2019)          | Ghana              | Gold- | Evaluating HIV prevalence variations in mining communities in Ghana         | Findings emerging from this study suggest high HIV prevalence in mining communities in Ghana due to high transactional sexual activities among women and the younger generations.                                                                                                                                                                                                                                                                                                                                                     |
| Kolie <i>et al.</i> , (2019) | Republic of Guinea | Gold  | Assess the environmental Impact of Lefa Gold Mining on Its Local Population | The results showed that the Lefa gold mine's activities contaminated the farmland (31.21%), allowed the extinction of many animals and plant species (28.19%), which caused the change of the landscape of the study area. In most mining communities, the degradation of land by LGM constitutes a major threat to agriculture and their economic survival. Much of the still available land has been contaminated with chemicals from mining activities which make higher the living cost and increase mortality rate and diseases. |

Source: Author's compilation from several sources.

All these studies reviewed above on the impact of mining activities on communities residing nearby mining operations point to the fact that mining activities have damaging effects on the environment, lives and livelihoods, exacerbating vulnerability of households. The results from the studies reviewed above were corroborated with the findings of the present study as discussed in chapters 6 and 7 below. The review was also critical in the crafting of recommendations on variables that should be considered in analysing and responding to mining disaster impacts on nearby households.

Just like the international empirical literature discussed above, South Africa, and the African continent is not spared from the negative environmental impacts of mining. For instance, Karombo (2016) argues that South Africa, just like elsewhere in Africa, experiences negative environmental impacts and risks due to mining activities. These risks or hazards are caused by, among others, river contamination due to chemicals used in mining activities as well as the improper rehabilitation of mines once they close which result in mine tailings. Karombo (2016) argues that in South Africa, tailings dams

are a major environmental risk from mining activities. The SADC region has also seen a number of studies on the impact of mining activities on the socioeconomic wellbeing of communities. Cronje *et al.*, (2013) argues that throughout the SADC region communities surrounded by mines have been negatively affected by mining activities that are detrimental to the environment. Negative impacts include dust and other particles in the air and water, excessive noise from blasting, and overcrowded and unhygienic living conditions. These in turn cause ill health in the form of hearing problems, TB, silicosis, asthma, cancer, diarrhoea, and other airborne and water associated illnesses. As communities bear these environmental threats, they also grapple with day-to-day social ills of urban townships in the SADC region, including poverty, unemployment, poor housing and infrastructure as well as health related challenges like high incidence of HIV and STI's, unwanted pregnancies, malnutrition, alcohol addiction and mental illness. Several SADC studies have focussed on the impact of artisanal mining on the socioeconomic wellbeing of surrounding communities.

Other studies have focussed on the impact of illegal mining activities. Good examples of such studies are those by Bhebhe *et al.*, (2013), Ncube-Phiri *et al.*, (2014). Bhebhe *et al.* (2013) observed that illegal mining activities cause severe environmental risks such as deforestation, open pits, increased siltation, soil erosion and water pollution due to mercury particles discharged from mining activities. Explosives used in these activities pose risk to people's lives. Similarly, Ncube-Phiri *et al.*, (2014) investigated the environmental impact of illegal gold mining activities in the Mzingwane District in Zimbabwe and noted that artisanal gold mining poses severe negative environmental risks to communities in the surrounding the area due to the heavy mercury discharged into rivers which contaminates water. Surrounding communities are vulnerable as are aquatic life and agricultural activities. Illegal mining activities pose other risks such as injuries and HIV/AIDS, and water shortages.

The SAHRC hosted a National Hearing in 2016 to investigate the underlying socioeconomic challenges of mining affected communities in South Africa. Communities surrounding mines tend to suffer from respiratory illnesses due to dust inhaled from mining dumps, and blasting operations that takes place in the mines. Some of the blasting activities cause damage to property and infrastructure in surrounding communities. Communities suffer from dust and noise pollution, acid mine drainage, as



well as water pollution due contamination of water sources by mercury effects. In another study, Winde and Stoch (2010) observed the huge impacts of gold mining activities in the Westonaria area on the environment. The impacts included land degradation caused by dewatering from dolomite and sinkhole formations, pollution of surface water, and contamination of water and soil by uranium particles. Furthermore, urban growth in the area has resulted in communities building shacks in places with old slime dams or near abandoned mining areas. This exposes households to health-related risks such as radiation, dust and tailings. Households locate themselves in such areas due to limited resources. Coetzee and Van Niekerk (2013) note that due to economic growth, the Gauteng province has recorded an influx of people to the area, giving rise to unplanned urban growth, which in turn results in crowded settlements, high levels of poverty and limited basic services. The vulnerability of households is further compounded by the fact that many are located in unsafe dolomitic areas.

Ngcobo (2006), Coetzee and Niekerk (2013), investigated disaster risk posed by dolomite in the Westonaria and North West Province, respectively. Coetzee and Niekerk (2013) noted that large parts of municipalities in the North West overlay dolomites and are prone to sinkholes, making, households in this area very vulnerable. Similarly, Ngcobo (2006), observed that households in the Westonaria mining area, which is predominantly a dolomitic area, face risks of flooding and sinkhole formation. The brittle mining area of Westonaria is also prone to seismicity due to mining. Mining activities in Westonaria cause dewatering which affects ground water levels and farmers who use the water for agricultural purposes. Groundwater is also polluted by waste dumps. The formation of sinkholes affects infrastructure in the area. Mining activities in the area have also attracted an influx of migrants, resulting in the mushrooming of low cost housing in the dolomitic area, thereby compounding the vulnerabilities of households to other disaster risks. In 2008, a study by Van Eeden *et al.*, (2008) confirmed the negative effects of mining activities on the environment and on water quality in particular in the WFS catchment area. The results of the study revealed that decades of gold mining activities in the area have exposed the WFS catchment area to environmental risks such as water pollution, dewatering, formation of sinkholes and harmful radioactive metals resulting in acid mine drainage. The dewatering of mines, which formed sinkholes in the area, posed further risks to infrastructure and buildings. Also, mine

effluents which contained mercury caused acid mine drainage and polluted nearby water bodies. Water pollution had negative effects on surrounding communities especially in the informal settlement. Informal settlement communities relied on this water for drinking and for agricultural activities. Likewise, Van Eeden *et al.*, (2009) emphasised that disaster risk in mining communities in the West and Far East Rand were due to increased urbanisation in the area, among other reasons. Due to rapid urbanisation, many households lived and worked near mine sites. Households were therefore predisposed of many mining related hazards. For instance, these sites were regarded as radioactive, which posed a health risk to many households.

Liefferink and van Eeden (2010), also reflected on the negative effects of gold mining activities in the West Rand. They noted that the West Rand area is not only faced with acid mine drainage, but other environmental disasters such as sinkholes, water pollution, dust and health related issues. The same issues as discussed above, were also found in a study by Koen *et al.*, (2017). The authors investigated the impact of mining activities on the wellbeing of communities in the Bekkersdal area. The results of the study indicated that the decline in gold mining in the area has had multiple unique effects on the community. Largely, the decline in mining activities has negatively affected the wellbeing of the Bekkersdal community. The community suffers from air pollution due to mining activities and dust, land pollution due to waste, litter and untreated sewerage, water pollution due to open canals, and unemployment, poverty, broken families – with orphans living with their grandmothers –, illnesses such as those related to HIV/AIDS, and lack of resources, including school, skills and basic services. Gold mining activities in Bekkersdal have contributed to environmental risks such as water pollution due to mercury effects, acid mine drainage in the Upper WFS due to radioactive elements residue that also cause many sicknesses, with respiratory diseases being pronounced. The upper WFS is characterised by informal settlements which are built on dolomitic areas which cause sinkhole formation.

Durrheim *et al.*, (2006), evaluated the impact of seismicity of gold mining in Klerksdorp in the North West province. The results of the study indicated that past and present mining activities in the area do trigger seismic events, which affects several buildings and infrastructure surrounding the gold mining areas.

Kunene (2020), conducted a case study of social vulnerability to seismic events due to mining activities in the Khuma Township, in Klerksdorp, in the North West Province. The study found that Khuma township communities were exposed to seismic events due to mining activities in their surroundings and that households were socially vulnerable as the seismic events primarily affected the houses of poor households, as they were poorly constructed. Thus, the findings of the study were in line with the PAR model on the social vulnerability dimension and the root causes that expose societies to socioeconomic and environmental vulnerabilities.

Ackerman *et al.*, (2018), assessed the socioeconomic and environmental consequences, as well as the vulnerabilities of communities as a result of two mine closures in the Springs, Aurora-Orkney and Grootvlei, area of Ekurhuleni Metro in the Gauteng province. The findings of the study revealed that the community has been exposed to environmental risks in the area such as acid mine drainage. The flooding of mineshafts and polluted mine water poses serious health risks to the community. Residents who sometimes use untreated mine water to irrigate their gardens were highly exposed. These challenges are compounded by other prevailing urban township challenges such as unemployment, lack of skills, depression, domestic violence, substance abuse, limited access to basic services, and the proliferation of informal settlements.

In another study of gold mining activities in the Ekurhuleni municipality, the Water Research Commission (2009), found that mining activities in the area had resulted in environmental risk such as contamination of ground and surface water by mercury and other metals while water quality had been affected by acid mine drainage due to mining effluents. Blasting vibrations from mines caused damage to property and infrastructure in surrounding communities. Livelihoods (which are dependent on water and agricultural activities) and the health of the people had been adversely affected. The Water Commission (2009), also found that in the East and West Rand of Johannesburg, shacks were built on or in close proximity to the tailings dams, which caused further environmental risks. Abandoned mining pits in these areas (Ekurhuleni, East and West Rand) became breeding grounds for malaria-causing mosquitoes during rainy season. Other social effects identified in the area and attributed to mining activities were prostitution and migratory labour.

Thus, literature reviewed on mining activities in South Africa and around the African continent has presented results that are similar to those recorded in international literature, primarily showing that mining activities have negative environmental outcomes which exacerbate the vulnerability of households that are already susceptible to the conditions in the urban townships where there are many overlapping socio-economic ills.

The next subsection reviews empirical literature that compares household or community vulnerability and measures that are often adopted to ameliorate such vulnerability.

### **3.5 COMPARATIVE STUDIES ON HOUSEHOLD VULNERABILITY**

As discussed in Chapter 2, comparative research on vulnerability is considered a 'new methodological technique' which has the potential to offer new opportunities to revise old techniques for approaching the questions of vulnerability (Peacock, 1997, Becarri, 2016, Fernandez *et al.*, 2006). Comparative research also offers the opportunity to learn from outcomes achieved in similar contexts, thereby ensuring policymakers and practitioners avoid making past mistakes and are supported to use resources efficiently in current and future policy responses and on-the-ground interventions.

Ta and Atoner (2013) compared the vulnerabilities of informal and formal sector households in Turkey. Data for their study was gathered through a survey using a questionnaire. The main finding of the survey was that households in informal dwellings were more vulnerable to disasters than those in formal settlements. The informal households were not endowed with assets in comparison to the latter (formal settlements). Respondents were also questioned about measures they thought should be taken to minimise vulnerability. Their responses indicated the following: prevention of informal or illegal construction, avoidance of construction along river banks, construction of storm water collection systems, and the control of water levels in dams through opening outlet valves at regular intervals. Ta and Atoner (2013) adopted a case study approach to their study, as is the case with the present study.

Another study to compare the vulnerability of households in formal and informal areas in Turkey was conducted by Parker (1994). The aim of this study was to understand the underlying causes of household vulnerability in the two sectors so as to properly target

vulnerable groups. For disaster practitioners this study offered a chance to improve their prevention and mitigation strategies. The findings of the study indicated that households in the informal settlements of Istanbul were the most vulnerable to disaster risks as they were located in the more disaster prone areas compared to those who lived in the formal areas. Informal settlements are located outside planned and regulated environments. To minimise risks, the government placed emphasis on public awareness to discourage people locating themselves in disaster prone areas.

Becarri (2016), also undertook a comparative assessment of vulnerability of communities at subnational level. This study took into account the economic, political, social and environmental factors of the households. Based on survey data, this study observed that social aspects accounted for 34% of household vulnerability, environmental aspects 25%, economic factors 20%, the built environment 13%, while environmental aspects accounted for 6% of household vulnerability and other factors 3%. The variables mentioned in this study were taken into account in the present study and the results are discussed in Chapters 6 and 7 further on.

Another study that compared the vulnerability of formal and informal sector households was conducted by Fernandez *et al.*, (2006) in Brazil. Informal settlements were found to be characterised by population increases in unplanned areas and that posed danger to households. The study was based on survey data that differentiated formal and informal households. In line with studies reviewed above, informal households were found to be more vulnerable than formal households. The study offered specific measures to address vulnerability, and these included political commitment and good governance, risk identification and assessment of the socioeconomic impact of disasters, the need to improve and manage communication for risk reduction methods, and capacity building. The measures identified in this case study, informed recommendations set forth in the present study. Richmond *et al.*, (2015), compared vulnerability of households across four countries, that is, Malawi, Uganda, Rwanda and Ethiopia. The aim of the study was to compare household vulnerability between these countries and develop a vulnerability model which can be applied in vulnerable countries to offer insights into the drivers of vulnerability. Across the four countries, it was found that the most vulnerable areas were those with lower access to clean water, electricity, transportation networks and healthcare. The common drivers of vulnerability in these four countries were identified

as class conflict, access to basic services, drought, population growth and diseases – as found to be the case elsewhere according to the literature reviewed above.

Abunyewah *et al.*, (2017) also examined the vulnerability of households in informal settlements. This study focused on informal settlements<sup>4</sup> in Bangkok, Thailand. As a first step, a detailed risk profile was conducted so as to be able to address the disaster related impacts in the area. The findings highlighted that knowledge of informal settlement demographics and financial, social, location and environmental aspects was key to managing disaster risk profiles in the informal areas. Further, the study indicated that informal settlements were located in disaster prone areas such as flood plains and valleys and had limited coping capacity, high population density, and characterised by poor planning and housing. Also, households who reside in informal areas were mostly migrants, who have low economic capabilities and limited access to political power. Inhabitants of these informal areas had poor education levels and were of diverse cultural and linguistically groups, making communication difficult especially when disaster strikes. These socioeconomic and environmental features found in the study, are similar to the Bekkersdal community socioeconomic and environmental factors to be discussed further in Chapter 4 of this study.

Morin *et al.*, (2016) examined the vulnerability of informal settlers in Manila, Philippines, using a hybrid of the ACCESS and the PAR models, as well as the sustainable livelihoods (SL) analytical framework. The model focused on household vulnerability, and highlighted the drivers of vulnerability of informal settlers, with a survey approach used to generate the data. The study found that the most vulnerable and most excluded households in area included large families with many dependents, those with illiterate household heads, the elderly and very low-income households. This study further proposed measures that can be used to address vulnerability, including empowerment of informal settlers by increasing their access to resources, or removing existing barriers to access to physical, social, financial, human and natural resources. Additional measures recommended highlighted the need to provide education and training, updating the census to ensure inclusivity and effectiveness, improving community participation, improving land tenure security and ensuring provision of basic services.

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<sup>4</sup> Squatter settlements, slums, unplanned towns and shantytowns are terms used interchangeably in literature.

The measures highlighted in these studies and the variables used to inform the findings were taken into account in the analysis of findings and the recommendations of the present study as presented in Chapter 7 of this study.

Maripe and Setlalentoa (2016) interrogated measures used to reduce disaster vulnerability in Botswana. The study covered three communities. It adopted a mixed qualitative and quantitative research method. The sample consisted of 3 567 people for the quantitative part of the study, and 120 participants for the qualitative aspect. In terms of gender representation, males and females comprised 40% and 60% of participants, respectively. Some of the key results of this study show that whereas disaster risks were a growing and common threat in the area, there were disaster management committees which were only active during emergency responses and failed to assist during the pre- and post-disaster phases. Furthermore, 87% of communities were vulnerable to various disaster related events, an indication that communities were weak in terms of community preparedness, response and resilience to disasters. Vulnerability was largely influenced by age, gender, marital status, employment and educational status. These findings and the mixed methods approach were instrumental in the design of the research approach and questionnaire instrument used in the present study.

As discussed above, the Food Agriculture and Natural Resource Policy Analysis Network (FANRPAN) developed the Household Vulnerability Index (HVI) statistical tool to quantify household vulnerability in 2004. The tool, which has been used in a number of SADC countries, is a composite measure that comprises 15 indicators of household vulnerability. The HVI has been tested in particular to evaluate household vulnerability to climate change in SADC countries, specifically in Botswana, Lesotho, Namibia, South Africa, Swaziland, Zambia and Zimbabwe. To refine the tool, a repeat exercise was undertaken in 2007, in three of the seven countries, that is Lesotho, Swaziland and Zimbabwe.

Largely, all seven country studies confirmed that the HVI tool is useful for planning and policy development because it provides a yard-stick for determining the extent of certain social challenges and thus makes it possible to measure the progress of a particular development strategy or policy on a time series and linear scale. The HVI tool has its

own limitations. First, it does not have costs of assets and services attached to it. Second, the tool does not account for gender dimensions of vulnerability. It is not premised on the notion that women are among the poorest of the poor in the absence of better opportunities, and that patriarchy, as seen across the region, prevents them from being economically independent.

The FFC (2014), applied the HVI tool on South African data. The study evaluated household vulnerability to climate change disasters, food and water insecurity so as to provide a basis for strategic interventions to targeted beneficiaries. This vulnerability assessment identified households that are vulnerable, the factors they were vulnerable to, in what ways, and in which locations. The gender dimensions of vulnerability were key elements of the study. The study was supported by data generated through a structured questionnaire, administered on a random sample of 3 000 households in two provinces of South Africa; Eastern Cape and Limpopo. The sample was divided equally between the two provinces. The two provinces, Limpopo and the Eastern Cape, were selected because they are on record as the poorest provinces in South Africa, they have the highest incidences of unemployment and are mainly rural and highly dependent on rain-fed agriculture.<sup>5</sup> The results of the study suggested that maize production will be severely affected by climate change both in Alice (Eastern Cape) and Lambani (Limpopo) by the mid-21<sup>st</sup> century.

Results of the study indicated that vulnerability increases with age and that vulnerability has gender dimensions, with female-headed households being more vulnerable than male-headed ones. Participation in formal village savings schemes and extension services were found to be key to minimising household vulnerability and having some knowledge of climate change was found to reduce household vulnerability. Households with knowledge of climate change tend to adapt and mitigate the impacts of climate change better. Overall, the results of the FFC study (2014) suggested that asset holdings is important in defining household vulnerability. This implies that a programme that helps to build the household asset base would go a long way in strengthening the

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<sup>5</sup>South Africa Policy on Agriculture in Sustainable Development,  
<http://www.nda.agric.za/docs/Policy/SustainableDev.pdf>



resilience of households when subjected to external shocks caused by climate change. The present study follows the FFC (2014) model closely and included the five capitals in its investigation to be discussed later on in Chapter 5.

Solik and Rowsell (2016), examined vulnerability to flooding in the Eden district municipality in the Western Cape Province, using a case study approach. The study highlighted the poor performance by local municipalities in implementing flood policies in the area, due to among others, the need to balance the pressing socioeconomic challenges against planning for disaster risk management, lack of human and political capital to implement central government directives and lack of integration between the various levels of local and central government. A key lesson learnt in the study was that flood policies need be embedded within the structures, processes and practises of the municipality. The findings of the study highlighted household vulnerability challenges which most municipalities experience. The study also highlighted challenges that district officials responsible for disaster risk management face in some municipalities; challenges also observed in the present study as highlighted in Chapters 1 and 2, with specific findings presented in Chapters 6 and 7.

Marais *et al.*, (2018) assessed the vulnerability of formal and informal mining communities in Postmanburg in the Northern Cape to the negative impact of mining activities. The study observed that mining activities encourage the growth informal settlements as most of the workers were contract workers. Typically, these informal households were more vulnerable as they have lower or limited access to basic services (water, sanitation, electricity) or resources (education/skills) than formal households. Jordaan *et al.*, (2019) conducted a case study of the WFS catchment area investigating the impact of anthropogenic factors such as mining activities, urban and rural settlements, sewerage works and agricultural activities on farms as well as the formal and informal settlements in the area. The study found that composition of bacterial communities differed significantly between less (downstream) and more (upstream) polluted sites. It was found that the anthropogenic disorder such as mining, urban and rural settlements, sewerage works and agriculture negatively affected freshwater systems and water quality, as well as ecosystem health. Also, the lower WFS river had the highest river contamination from mercury due to mine waste from gold mines, domestic wastewater treatment plants, urban and informal settlements as

well as agricultural runoff; resulting in the quality of water in the river being poor. These findings were corroborated by the results of the present study as discussed in chapters 6 and 7, respectively.

Winde (2010) quantified the levels of uranium pollution in gold mining areas in the WFS. The study found that underground water with uranium particles has been the source of waterborne pollution in the area, whilst the WFS also has tailings deposits as well as sinkholes. Uranium chemicals have damaging environmental impacts and negative effects on livelihoods based on agriculture, water related activities and the aquatic environment. Winde *et al.*, (2019) conducted a study of human exposure to uranium in the gold mining areas in the Witwatersrand basin. Nine wards were selected for testing uranium exposure due to the gold mining activities in the area. Six out of the nine wards selected for the study were in the West Rand which is close to upper WFS. The results of the study indicated that communities, particularly informal households, live close to mine tailings and are exposed to higher levels of uranium chemicals which adversely affect their health, causing diseases such as cancer. The study also revealed that exposure to the metal has other adverse health consequences as households inhale tailing dust, and the water communities access is polluted. Sari *et al.*, (2016) conducted a comparative research study of gold mining and non-gold mining areas to determine community vulnerability in Indonesia. To carry out this study, four community vulnerability indicators were selected; exposure degree, contamination rate, chronic, and acute toxicity. Each indicator used different samples, such as wastewater from gold mining process, river water from Tajum River, human hair samples, and a health questionnaire. The results of the study showed that concentration of total mercury was higher than the maximum mercury content permitted in the area. The mercury concentration in hair samples obtained from people living in the research location was considered to indicate the health quality. It was found to be the highest concentration of mercury across all samples. Thus, based on total mercury concentration of the four indicators, the community in the gold mining area were vulnerable to the mercury effects than communities in non-gold mining areas. These results are in line with literature reviewed in Chapter 2 above were corroborated with findings to be discussed in Chapters 6 and 7 below.

French *et al.*, (2017) assessed the hazards and vulnerability related to water availability and quality as affected by mining activities in Bolivia. The study was composed of two communities in the area: communities without mining activities versus communities surrounded by mining activities. Agriculture was the main economic activity in the municipal area where the study was conducted. Findings of the study highlighted that the majority of people surveyed had limited access to potable water, education levels were up to primary levels, they had limited income as well as social cohesion. Also, water was found to be contaminated by metal related effects due to mining activities resulting in mine tailings and acid mined drainage, which in turn affected water quality supplied to the community for their livelihood. Health related issues were identified among participants, particularly respiratory and bacterial illnesses. In these two communities, the community surrounded by mines were vulnerable and exposed to water pollution, acid mine drainage and tailings.

Seymour (2005) argues whereas various incidents of mining disasters have occurred in countries such as South Africa, Australia and the United States, Zambia, Chile and Canada, for South Africa, the situation has been worse given the proportion of disaster incidents. Not only that, the country has highest number of dam tailings that are risky compared to other countries such as the United States, Brazil, Canada, Ghana, Mexico, Peru, Botswana and Tanzania (Reuters, 2020). These dam tailings are also found close to densely populated places of residence making them hazardous to the environment and people's livelihoods. The mining disasters in South Africa range from fires and explosions, flooding, and tailings and shafts collapse. Of the mining disasters mentioned above, explosions have been the most recorded due to gas build up, followed by fires and tailings due to disregard of practices for proper disposing of mining waste. The result has been many fatalities, loss of livelihoods and destruction of infrastructure and property.

Bury (2004), assessed the impacts of mining activities in three communities in Peru and Brazil. These three communities were categorised as follows; first community – directly close to the mine, had direct impacts; the second community – had indirect mining impacts, and the third community – had direct and indirect mining impacts. The results of the study highlighted that mining activities in the three communities have negatively affected the natural and social capital resources. For the first community, negative

impact was through environmental risk of water pollution because of mine effluents, which in turn affected community livelihoods. Also, in this first community, mining activities resulted in mine leaching, open mining pits and water diversions. Exacerbating the situation in this community was that the community was highly impoverished with no access to basic services, high levels of child malnutrition and limited access to infrastructure and roads.

The World Resource Institute (2003) conducted a case study in two countries; Philippines and Papua New Guinea to assess areas that are socially and environmentally sensitive to mining activities. It was found that communities in socially and environmental sensitive areas were within 10 km of mining activities exposing the community to mining related hazards such as high seismic events and water pollution. These areas were also characterised by social and environmental ills and as such vulnerable to mining activities due to a long list of issues, among them: low levels of education, limited income, lack of basic services, high unemployment, unequal distribution of wealth, high corruption levels and non-adherence to the rule of law, stressed watersheds (scarce water resources), deforestation due to mining activities, displacement of communities which resulted in disruption of livelihoods (domestic violence, prostitution, alcohol abuse), earthquakes, and acid mine drainage on land or rivers which contaminated the environment.

Wolkersdorfer and Howell (2014), contend that in Europe just like elsewhere in the world, mining activities have over the years declined and in turn created abandoned mines. As a result, water pollution from abandoned mines has been the cause of concern in the United Kingdom (UK), where mine water pollution has been identified as one of the greatest form of aquatic pollution. In Estonia, the situation has been similar, with the closure of mines leaving abandoned mine pits which get flooded when rain falls. At the same time, ground water levels have decreased in the area due to mining activities, which have also caused contamination of water by acid and metals. In the Netherlands, closure of mines resulted in rise in acid mine water. In Slovakia, mineral deposits from mining posed environmental risks such as acid mine drainage due to water being contaminated by mercury metals, thereby affecting water supply and quality. Likewise, in Austria, abandoned mines have been the cause of water pollution due to heavy metals that contaminate water. In Hungary and Italy, mining related

activities impacted the environment, the dewatering of mines formed sinkholes and acid mine drainage has impacted ground water used for water supply. Wolkersdorfer and Howell (2014), argue that in these countries, even mines that have closed pose environmental risks such as water pollution, acid mine drainage, tailings, and dewatering which leads to flooding and sink holes.

Friends of the Earth (2007), argue that, generally, impacts of mining activities on the environment are severe, and include toxic spills which affect the livelihoods of communities and biodiversity. They are of the view that, gold mining activities cause environmental disasters due to dumping of toxic waste tailings directly into rivers. For instance, in Romania, Hungary and Indonesia, mining disasters have occurred due to dumping of mine waste, and water pollution has affected, in some cases destroyed livelihoods based on water availability and agricultural activities. In Chile, mining activities have resulted in communities protesting against water shortages as mining activities required large amounts of water for processing. In Niger, mining activities have been the cause of exposure to harmful elements (radioactive materials) and mine tailings, which in turn affect the environment and have been cause of land and water pollution. Whilst in Philippines, closed and abandoned mines 'became a ticking bomb for the environment' due to the impact of mine effluents such as acid mine drainage effects.

Pokorny *et al.*, (2019) assessed gold mining effects on households in Burkina Faso and the survey was conducted in six districts. The study revealed the negative effects of gold mining activities on communities that have limited education and poor access to markets. Lack of education or other resources makes it difficult for those communities to cushion themselves against mining disasters. Also, it was found that districts that had access to resources fared better than those with less access to resources such as basic services, infrastructure, health and market services. Thus, whereas gold mining activities in Burkina Faso had environmental, economic (environmental degradation of land) and social (less resources) impacts, the severity of impacts differed depending on accessibility of resources with respect to the districts.

In Tanzania, Charles *et al.*, (2013) assessed the impact of gold mining on five villages. The results indicated that the environment was contaminated by mercury effects due to

gold mining. Communities residing close to the gold mining were vulnerable to these mercury effects, which also caused health related impacts in the form of birth defects and skin discoloration among infants. Further, these villages had limited infrastructure services and educational attainment – thus compounding their vulnerability. The World Bank (2015) investigated the socioeconomic effects of gold mining in Ghana. The study noted that due to mining activities in the area, there was a decline in agricultural productivity in nearby communities. In addition, it was found that access to basic services was a big challenge to migrants compared to non-migrants. Also, Danquah (2017) studied the effects of gold mining activities on rural households in Ghana. The study employed both quantitative and qualitative methods so as to analyse the extent of the threat posed by mining activities on assets and rural livelihoods. The findings of the study showed that of the livelihood vulnerability index dimensions, households were more vulnerable to the impact of mining activities along the social, physical and human capitals, whilst natural and financial capitals were found to be moderately vulnerable compared to that of the non-mining communities. In addition, households in the mining communities had a better wellbeing compared to the non- mining activities.

The literature reviewed on comparative assessment, both the local and international literature, revealed that in urban townships the effects of negative environmental impacts of mining activities are damaging to lives, wellbeing and the environment of households residing nearby mining sites. The situation is worse for informal households and migrants living nearby mining areas than for their counterparts living further from mines due to other social ills. In addition, some of the mining disasters occur due to non-compliance with safety measures by mining companies. All these findings shed some light in terms of the analysis presented in Chapters 6 and 7 and informed the crafting of the subsequent recommendations.

### **3.6 CONCLUSION**

Chapter 3 expounded on empirical studies on disaster risks and vulnerability, including vulnerability of households in the surroundings of mining areas. The empirical literature indicated that there are a variety of measures used to measure disaster risks and vulnerability, ranging from the use of indices, case studies and survey approaches.

The use of indices suggests that vulnerability is influenced by, among other factors, the socioeconomic, demographic and environmental circumstances surrounding households. Also, indices assist, among other things, as an early warning system to disaster practitioners to plan to prevent and reduce disaster impacts. These indices further assist in identifying vulnerable groups in society. However, the downside on the use of vulnerability indices is their subjectivity which requires constant and continuous empirical scrutiny to ensure their robustness. Case study approaches and surveys have been used to assess vulnerability to disasters risks. The case study approaches and surveys indicate that livelihood variables should be taken into account when measuring vulnerability of households as they become exposed when there is lack access to resources. Both local and international empirical evidence shows that residing in mining areas has devastating negative effects on livelihoods and resultant environmental degradation exacerbates socioeconomic and wellbeing challenges of the households and communities.

Comparative assessment both from local and international literature revealed that in urban townships the effects of negative environmental impacts of mining activities are damaging to wellbeing and the environment of households residing nearby. The situation is worse for informal households, for migrants, and for households living nearby mining areas than their counterparts (formal areas) due to high levels of social ills in informal settlements. In addition, it was shown that some of the mining disasters recorded would not have occurred were it not for irresponsible gatekeeping in governing sectors and non-compliance with safety and care regulations by mining companies in communities from which they draw their employees. The indices, case study and survey analysis approaches highlighted various dimensions that need to be taken into account when measuring household vulnerability. Some of the measures have been adopted in the data gathering and analytical methodology of the present study, with results thereof reflected in the relevant discussion chapters. As historical context of a space like Bekkersdal is viewed as necessary to understand the rest of the chapters, Chapter 4 engages with profiling the town and region past development towards its current status.

## **CHAPTER 4**

### **DISASTER RISK AND VULNERABILITY: BEKKERSDAL PROFILE IN HISTORICAL CONTEXT**

#### **INTRODUCTION**

The present chapter provides an in-depth analysis of the historical profile, socioeconomic context and the vulnerability to disaster risks of informal and formal households in the Bekkersdal area. This investigation was in the form of a case study of Bekkersdal, a township found approximately 60 km from Johannesburg, and located in the Rand West local Municipality (WRDM, 2011/12, STATS SA, 2011). The community of Bekkersdal has experienced a significant number of disaster risks in the recent past predominantly as a result of veld fires, flooding and incidents that occur as a result of mining activities. As in many townships of South Africa, the population of Bekkersdal lives in vulnerable conditions due to high levels of poverty, poor standards of living, unemployment, unequal distribution of asset ownership, lack of access to resources, slow growth of the local economy and widespread environmental degradation, among others (COGTA, 2005, WRDM, 2017/18, RWC, 2016/17).

An important character of the population dynamics in South Africa is the large number of households residing in informal settlements, of which Gauteng province has the highest number of such households in the country. Estimates place the proportion of households living in informal settlements at 76% in South Africa (Housing Development Agency, 2012). Gauteng province has the highest number of informal dwellings<sup>6</sup> across all provinces in South Africa accounting for about 40% (878 246) of the total number of informal dwellings countrywide (STATS SA, 2016). The STATS SA Community Survey (2016) highlighted five main challenges that households believe their respective municipalities within the nine provinces need to address. These challenges include lack

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<sup>6</sup> Informal dwelling includes: informal dwelling/shack in backyard, informal dwelling/shack not in a backyard (for example in an informal/squatter settlement or farm). Formal dwelling includes: formal dwelling/house or brick/concrete block structure on a separate stand or yard or on a farm, formal dwelling/house /room/flat in a backyard.



of safe and reliable water supply, lack or inadequate employment opportunities, the high cost of electricity, inadequate housing, and violence and crime. These challenges bedevilling Bekkersdal are therefore not unique, but affect many municipalities in South Africa, albeit to different degrees.

In addition to the challenges outlined above, informal settlements have the following features: illegality and informality, inappropriate locations, restricted public and private sector investment, poverty and vulnerability, as well as social stress (Banks *et al.*, 2020). Thus, informal households are vulnerable to disaster shocks as they lack basic services such as safe and reliable water supply, adequate housing, sanitation or electricity, there are few employment opportunities, and they face disproportionate levels of violence and crime (Housing Development Agency, 2012, STATS SA, 2016, Diedericks & Van Eeden 2019). Vulnerability to disaster risks is also heightened by poverty, population growth, unmanaged urbanisation, environmental degradation, civil strikes, lack of awareness and information, and misuse of technology (COGTA, 2008). In cities, vulnerability has also been associated with rapid urbanisation and improper planning, high population density, and inappropriate building construction, especially in the informal settlements (Parikh *et al.*, 2020; Satterthwaite *et al.*, 2020). Vulnerability in South Africa is inherently and directly associated with the history of the population in question (Apotsos, 2019, Liefferink, 2019).

Literature on disasters is clear that there is a strong and direct link between vulnerability to disaster risks on the one hand, and history, and political, socioeconomic and environmental circumstances of the community on the other hand (COGTA, 2005). South Africa has had a very difficult history under successive apartheid regimes, and this history has a bearing on people's vulnerability, as the politics of the day dictated where and how people lived, as well as how and where they earned their living. The Bekkersdal community has been predisposed to various disasters for a long-time (as alluded in chapters 1, 2, 3 and 4 of this thesis) and thus the history and political developments in the area could have contributed to the vulnerability of this community. It is a town that has developed against the backdrop of mining activities. This community of Bekkersdal has depended on mining (especially gold) activities since the 1940s. Although mining activities in the area have provided key means for earning livelihoods and development for this community, it has also posed significant risks to the

adjacent communities in the town of Westonaria where Bekkersdal is located (Lieberink, 2019). The community of Bekkersdal is located on a very brittle environment characterised by dolomitic ground and hundreds of sinkhole formations (Nealer, 2020). This chapter exposes this two-edged sword relationship between mining and community wellbeing in Bekkersdal.

Historical information on the study site will not only assist in contextualising current vulnerabilities but could also enhance our understanding of the differences in today's vulnerabilities. The sections that follow contextualise the Bekkersdal area, analyse its socioeconomic economic status, and outline the disaster risks (including the mining related risks) and vulnerability profile of the area.

## **4.2 CONTEXTUALISING BEKKERSDAL**

South Africa is made up of nine provinces, 44 districts and 257 local municipalities (Financial and Fiscal Commission, 2019, National Treasury, 2019). Bekkersdal township is in the Rand West (RWC) local Municipality, under the Gauteng province. Gauteng is one of the nine provinces and the most densely populated province in South Africa, with a population of 15.2 million as of 2019 (Stats SA, 2019). It is the economic hub of South Africa (Municipal IQ, 2020, WRDM, 2013). Despite being the economic hub of South Africa and boasting the largest GDP per capita, the Gauteng province has one of the highest incidences of unemployment and poverty (Stats SA, 2019, Municipal IQ, 2020), see Figure 12.1, Figure 12.2 and Figure 12.3.

The province of Gauteng has the highest population growth rates, due to, among others, inward migration from other provinces and from other countries in the region (Stats SA, 2019, Financial and Fiscal Commission 2019). The rapid population growth of Gauteng province has partly influenced poverty and unemployment. Many people who migrate to Gauteng in search of employment and better living, find themselves unemployed and living below the poverty line. As the mining centre of South Africa, many people from the rural province such as the Eastern Cape, Limpopo and KwaZulu Natal, and neighbouring countries like Zimbabwe, Mozambique, Eswatini and Lesotho, migrate to Gauteng in search of employment in the mining areas, especially the gold

mines. The gold mines have relied on low wage migrant labour from these neighbouring countries for decades. Historically, most incoming migrant workers failed to find employment. This, coupled with apartheid policies that sought to restrict the numbers of black workers living in cities, meant that many migrant workers found themselves eking a living out in the informal sector and residing in informal types of dwellings (Harrison & Todes, 2020)

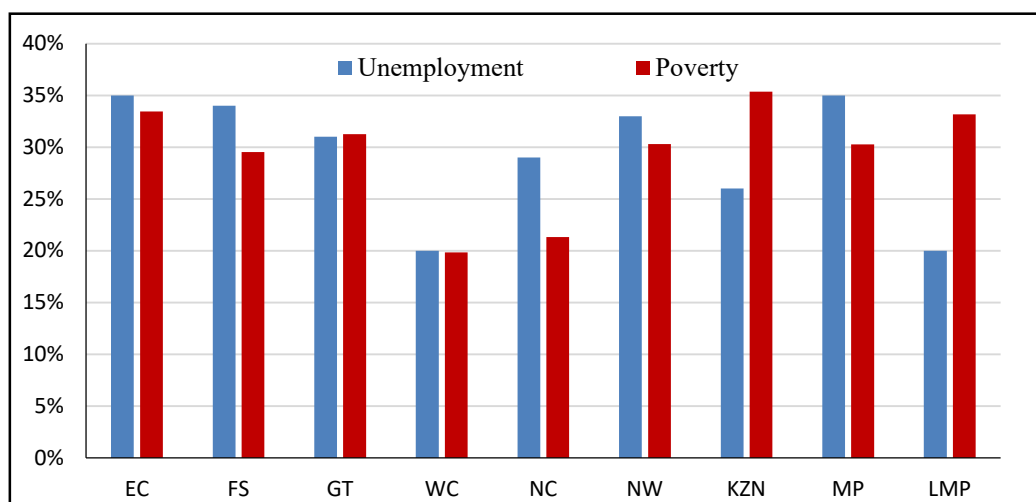


**Figure 12.1 Unemployment and Poverty**

Source: Financial and Fiscal Commission, 2019.

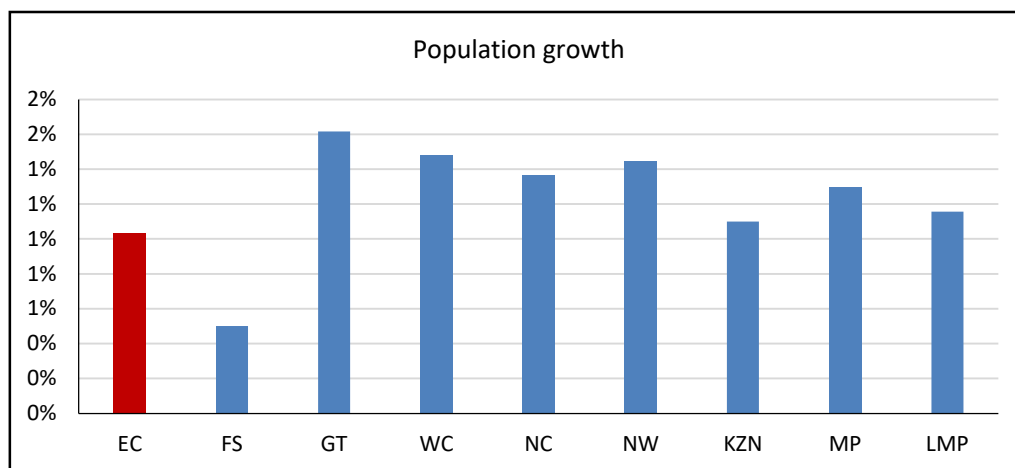


**Figure 9.2 Population Growth**

Source: Financial and Fiscal Commission, 2019.

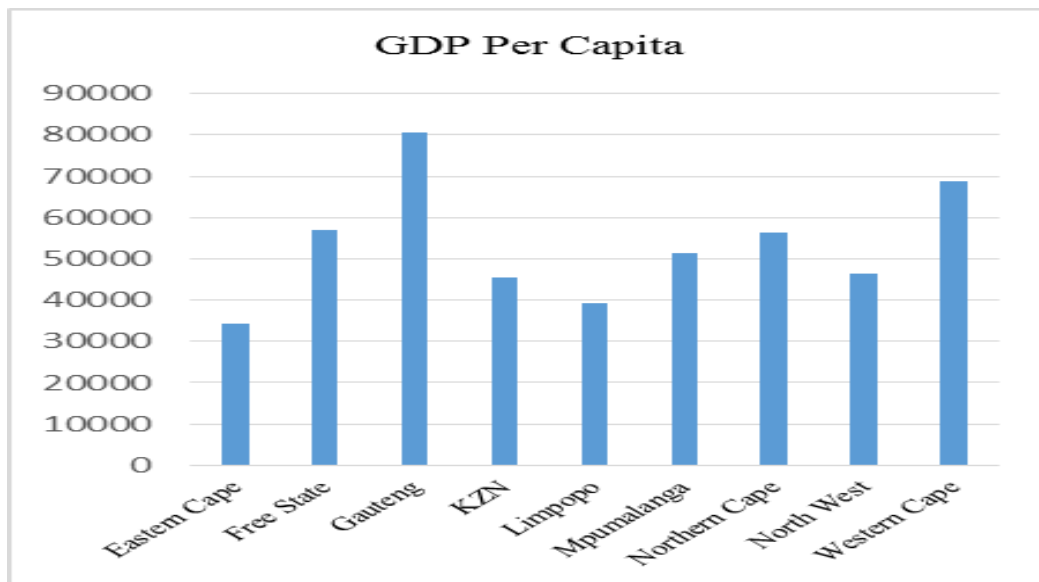


**Figure 10.3 GDP Per Capita**

Source: Financial and Fiscal Commission, 2019.

Figure 12.4 also shows that Gauteng province is the most unequal provinces in the country, with a Gini coefficient of 0.633 in 2016 (Financial and Fiscal Commission, 2019).

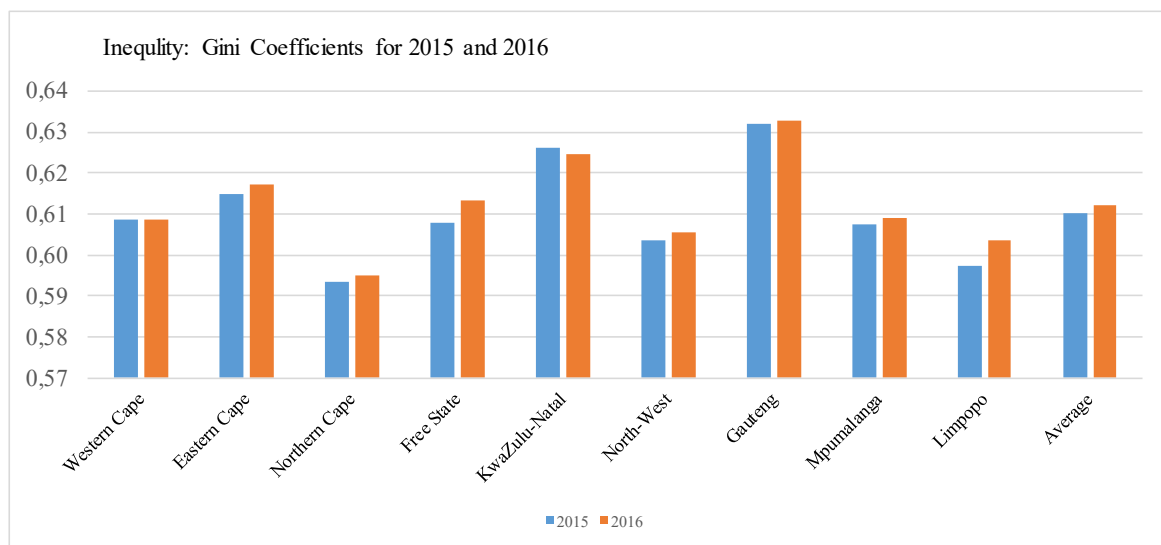


**Figure 11.4 Inequality: Gini Coefficients for 2015 and 2016**

Source: Financial and Fiscal Commission, 2019.

The Gauteng province has three of South Africa's eight metros; Johannesburg, Tshwane and Ekurhuleni. In addition, the province has two district municipalities, the Sedibeng and West Rand Districts. In turn, the West Rand District Municipalities (WRDM), which is located to the west of the Gauteng Province, has four local

municipalities; Mogale City, Merafong City, Randfontein and Rand West City local municipality. Rand West City local municipality was a result of the merger in 2016, of two local municipalities, Randfontein and Westonaria (where Bekkersdal is located), (STAS SA, 2016). Rand West City Local municipality is a category B municipality, mainly responsible for delivery of basic services to its locality. According to the Constitution, category B municipality share executive and legislative authority with a category C municipality, in this case the West Rand District Municipality (WRDM).

As noted above, the Rand West City Local municipality is located approximately 60km from Johannesburg. The Rand West City local municipality has several towns including Bekkersdal, which is the focus of this study (Figure 13). Bekkersdal township is situated 7km to the east of Rand West and 14km from Randfontein. According to the Municipal Demarcation Board<sup>7</sup> (2018), Rand West City local municipality had a population of 279 000 residents in 2019 (see Figure 14).

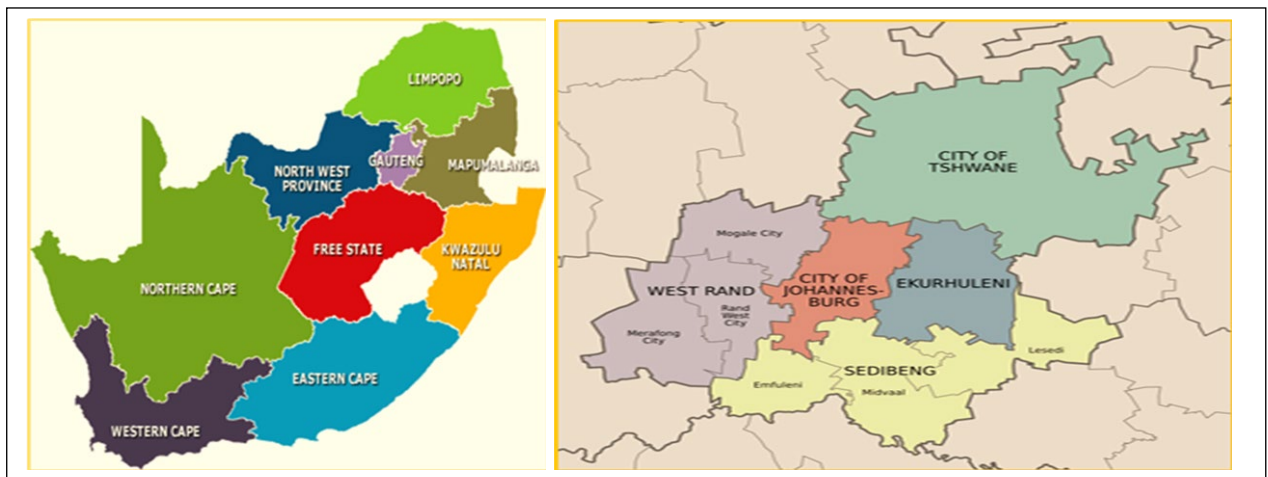


**Figure 12 Location of Gauteng Province, West Rand District Municipality, and Bekkersdal Town**

Source: Google Maps, Accessed on 15 April 2018.

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<sup>7</sup> The Local Government: Municipal Structures Act (1998) makes provision in Section 85 for the Municipal Demarcation Board (MDB) to assess the capacity of municipalities in terms of their functions as stated in the Constitution and to exercise their powers, and provide advice to MEC's responsible for Local Government.

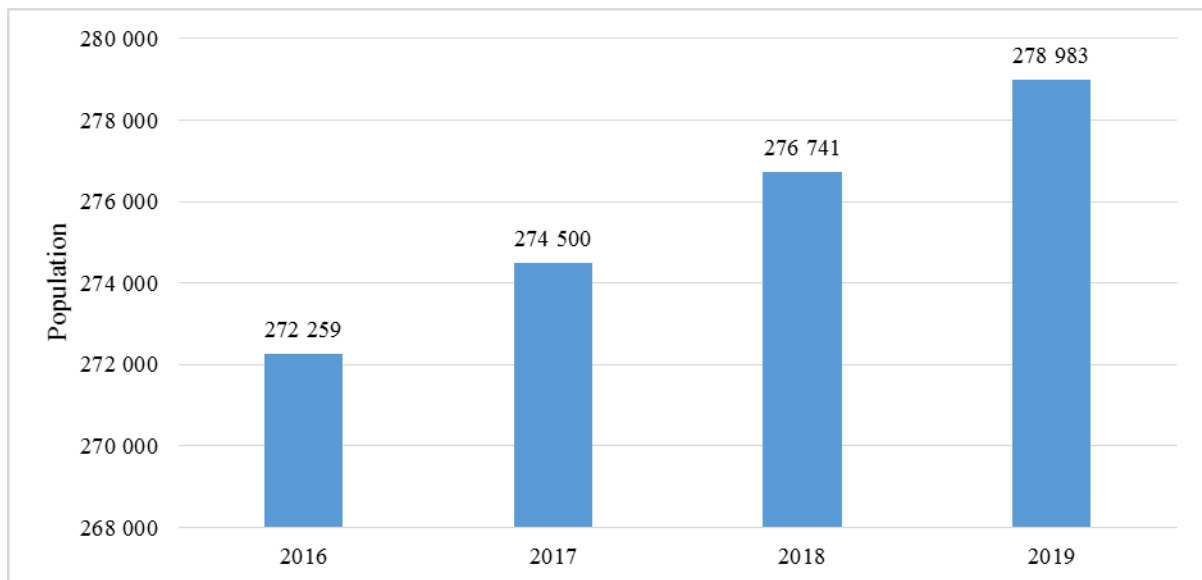


**Figure 13 Population of Rand West City Local Municipality**

Source: Municipal Demarcation Board, 2018 RWC Municipality.

Figure 15 shows that the RWC is mainly dominated by Africans at 78% of the population, followed by Coloured and Indians at 14%, and lastly Whites who constitute 6% of the population. Most of the population in the municipality is within the working age (30-64 years) with those between 5-19 years comprising 22% of the population.

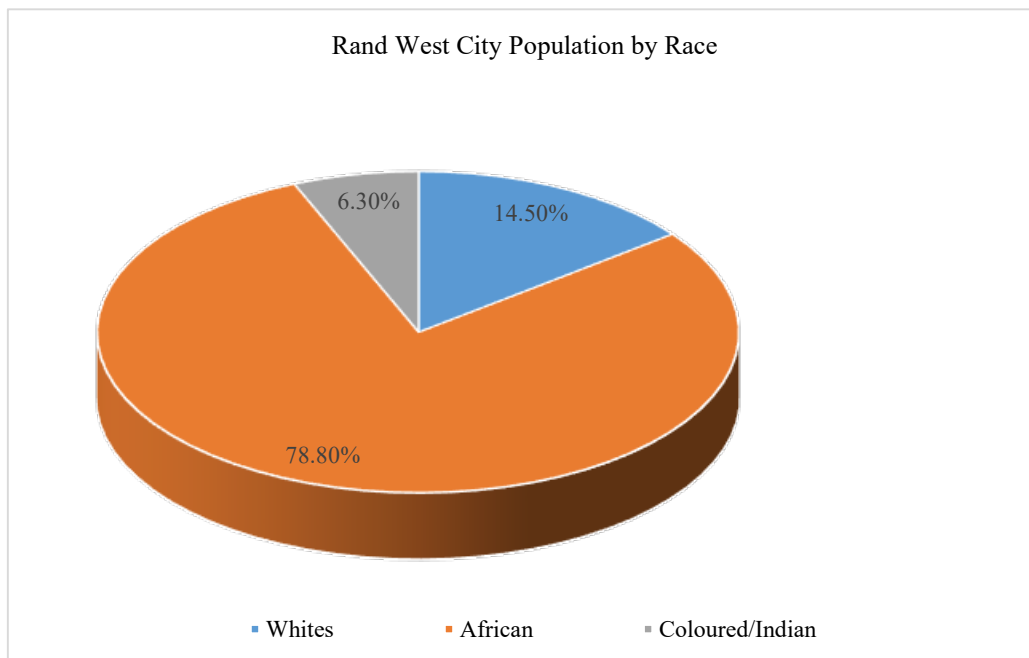


**Figure 14 Rand West City Population by race and age**

Source : Municipal Demarcation Board 2018, RWC Municipality.

The RWC was further differentiated by population size so as to elicit insights on inequalities that exists in the municipality. Figure 16.1 and 16.2 below shows the distribution of the RWC population by population density and land area occupied. The two diagrams show some inequalities; that more poor people occupy a smaller land area size, while a smaller size of the population comprised of well to do people occupy a large land area.

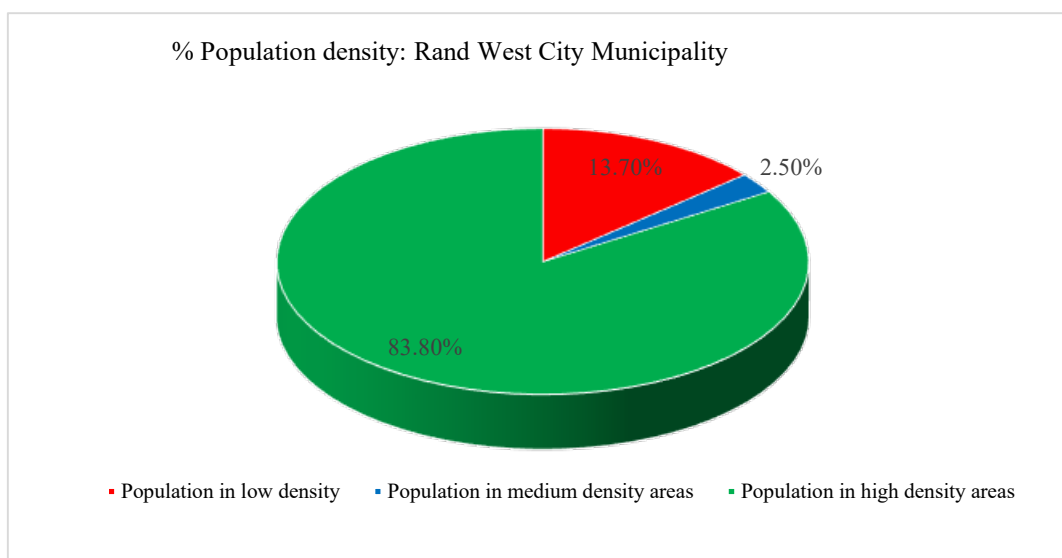


**Figure 15.1 Distribution of Rand West Population by density**  
Source : Municipal Demarcation Board 2018, RWC Municipality.

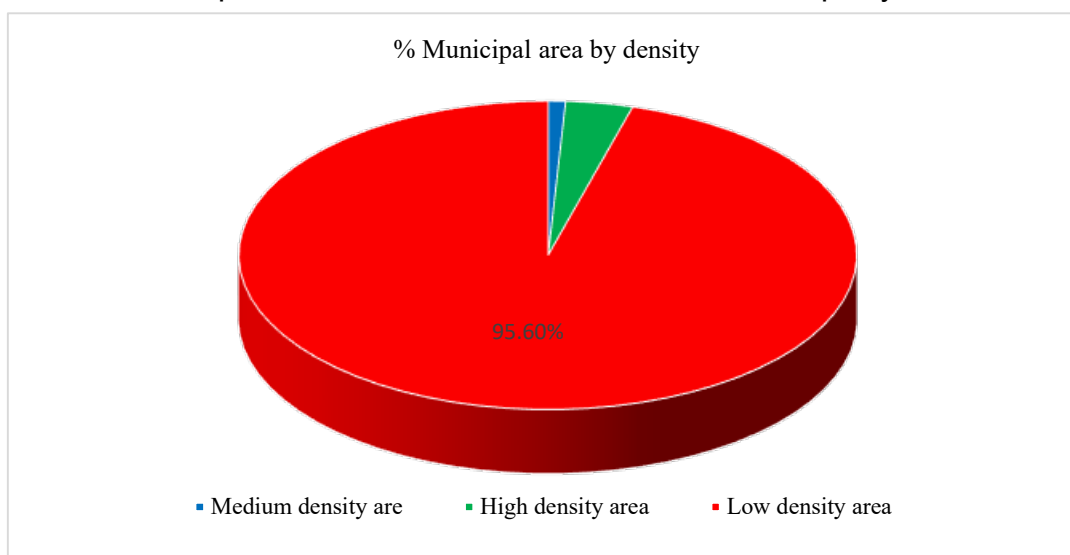


**Figure 16.2 Distribution of Rand West Population by area**  
Source : Municipal Demarcation Board 2018, RWC Municipality.



The Rand West City local municipality comprises 16 wards. Bekkersdal is made up of seven of the 16 wards (that is, wards 9 to 15). Bekkersdal has formal and informal areas. The township comprises of  $\pm 3,000$  formal households and  $\pm 13,000$  informal households (Lieberink *et al.*, 2017, Municipal IQ, 2014). The informal areas consist of Mandelaville, Winnie/Holomisa, Silver City, Spook Town, Thambo section and the X section. The formal areas are Bekkersdal Proper and Skierlik (see Figure 17). The map in Figure 17 gives a pictorial view of informal and formal settlements within Bekkersdal. In the next subsection the historical context of Bekkersdal is discussed, to outline the role of mining in shaping the Bekkersdal mining community in the RWC municipality.

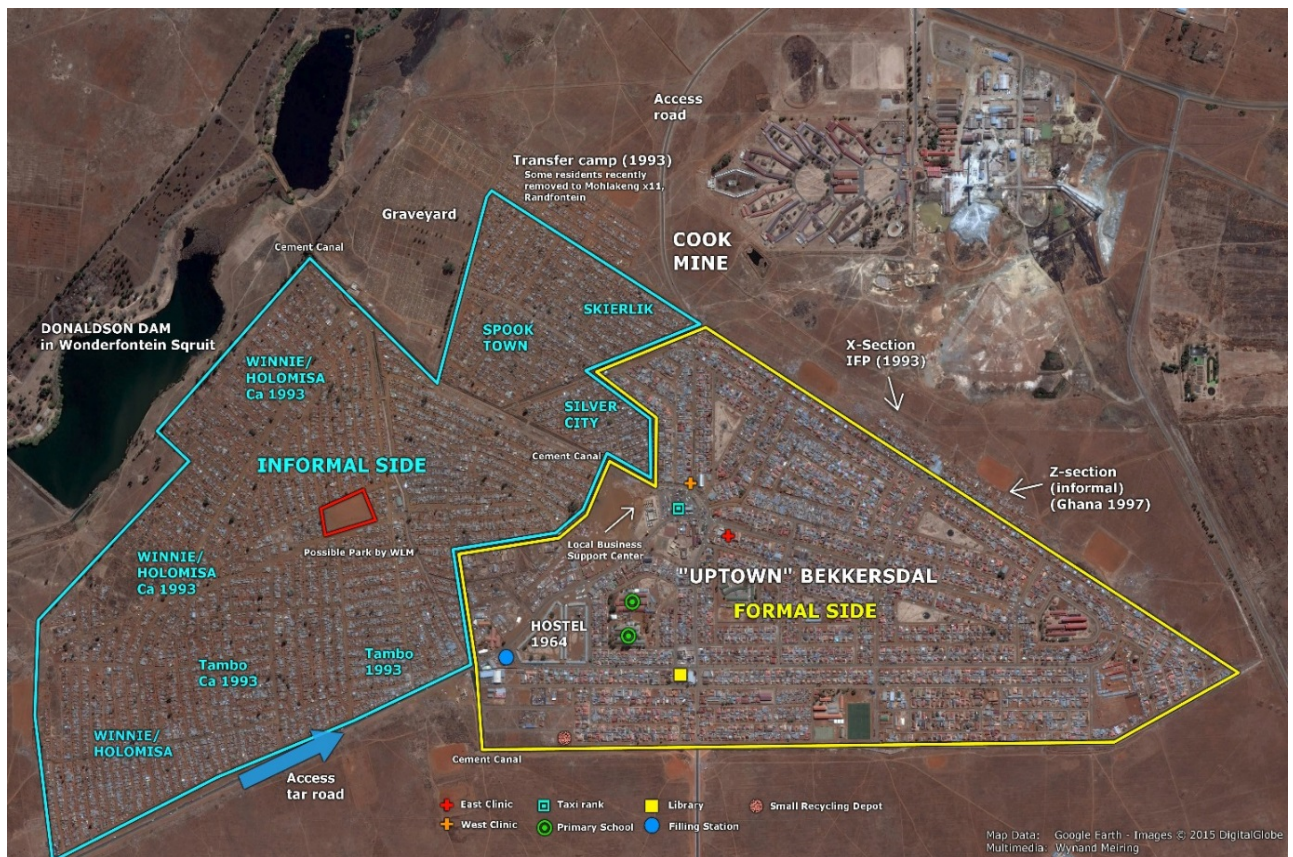


**Figure 17 The Bekkersdal Township (formal and informal)**

Source: Van Eeden and Khaba (2016)

#### 4.3 HISTORICAL PROFILE OF BEKKERSDAL

South Africa under the apartheid regime, had a bearing on people's vulnerability as the politics of the day dictated where and how people lived, as well as how and where they earned their living (COGTA, 2005, Apotsos, 2019). The South African Risk and



Vulnerability Atlas (2005) concurs and notes that the settlement landscape bears the evidence of South Africa's history of apartheid as there is concentration, inequalities, densely populated and dispersed settlements in cities.

Coetzee and van Niekerk (2013) argue South Africa's vulnerability can be explained by two key drivers, that is, the legacy of apartheid and the rapid uncontrolled urbanisation. The apartheid legacy resulted in limited availability of opportunities or resources for Black households as access to resources was determined and differentiated according to the colour of the skin, with Black households disadvantaged in access to land, houses, jobs and basic services (Coetzee & Van Niekerk, 2013, Van Eeden & Khaba, 2016, Masondo 2011). The rapid uncontrolled urbanisation was a result of in-migration with migrant workers looking for opportunities in mining or the growing industry. This resulted in people settling in informal settlements to be closer to areas of work and job opportunities. Concentration and inequalities were not only a feature of large cities, but they were also rife in areas characterised by densely populated and highly dispersed settlements. As such, the Bekkersdal community has been predisposed to many disaster risks for a long-time, with its history and political evolution contributing to the vulnerability of the community (WLM, 2011/12, WRDM, 2016).

The history of Bekkersdal township and its existence can be traced back to 1945 where it functioned under Act 25 of 1945, the Group Areas Act, which stipulated limited land occupation near places of industrial development (Van Eeden 2015, Khaba & Van Eeden, 2016). Bekkersdal township was founded in 1945 as a mining town (De Crom & Nealer, 2017). Mining has remained the main economic activity in the Bekkersdal township till today. The Witwatersrand Basin remains South Africa's largest gold resource with gold and uranium being the major economic contributors (WRDM, 2016). The first gold mine in the dolomite deposit was established in the 1930s (Van Eeden & Khaba, 2016). Through successive consolidation, most mines in the West Rand District are currently owned by five major mining houses: Sibanye Gold, Gold Fields, Harmony Gold, AngloGold Ashanti or Pan African Holdings (Van Eeden, 2011).

As the economy expanded due to mining activities, so did the demand for more workforce, with Bekkersdal attracting migrant workers from rural South Africa and neighbouring countries. This produced the direct link between rapid urbanisation in the

area and mining activities (Masondo, 2011, Van Eeden & Diedericks, 2016). Bekkersdal township was created and perceived to be a temporary settlement area to maintain and house black mineworkers working in nearby gold mines (WLM, 2011/12, Van Eeden, 2011). As a result, formal houses owned by the municipality were built in the area. However, by the late 1940s the rapid population growth and demand for housing outstripped supply in formal Bekkersdal, while basic services were also stretched (Khaba & Van Eeden, 2016). Koen *et al.*, (2014), Ryke *et al.*, (2015) argued that the rise in the informal settlement in Bekkersdal area started gaining momentum in the late 1960s. The rapid growth of the informal settlements in the Bekkersdal area was disorderly as settlements emerged in uncontrolled and unplanned areas, including in dolomite areas which tend form sinkholes. Van Eeden and Diedericks (2016) argued that the rise in informal settlements in turn resulted in increased demand for delivery of basic services in the area. Thus, population growth and the increase in informal settlements posed a threat to the environment of Bekkersdal. Basic services were not delivered and unavailable to all households as there was no control of where these informal settlements were built, posing threat to safety and the health of households (WRDM, 2011/12, RWC, 2017/18, Khaba & Van Eeden 2016). Van Eeden and Diedericks (2016) argued that the conditions of the informal settlements in Bekkersdal can be attributed to households being allowed to settle even in unsafe areas such as dolomitic areas. Therefore, development in the area meant cater for housing needs was undone by the non-suitable dolomitic land and location of settlements close to the mines (RWC 2017/18).

According to Khaba and Van Eeden (2016), the discontent with service delivery in the Bekkersdal area has been in existence since the 1970s till today. As a result, Bekkersdal has been labelled the outmost “unstable, violent and controversial township”. Van Eeden and Diedericks (2016) argued that, in South Africa, poor service delivery has been identified as one of the distinct challenges facing not only Bekkersdal community but the country as a whole. The native settlement act of 1945 was the main reason for the fragmented housing arrangements among black communities since the outbreak of the Second World War (Van Eeden & Khaba, 2016). These housing arrangements created and reinforced social divisions between households as well as

the different types of accommodation and as such, the act reinforced inequalities and class differences in the provision of housing and other services (Masondo, 2011).

Class dynamics and conflicts started to arise in Bekkersdal in the 1960s as a result of demand for limited resources (Masondo, 2011). These class dynamics and differences were between homeowners, council tenants, backyard shack tenants, squatters and hostel residents. According to Masondo (2011), households who lived in council houses tended to belong to an older generation of unskilled manual workers who earned low wages due to low levels of education. Other households were in occupational mobility jobs (clerks/administrators and semi-professional) and became homeowners in the housing schemes developed by the private sector. The backyard shack tenants consisted of the younger generation who did not complete schooling and were in low paid jobs, and as such, could not afford to buy houses. The squatters also consisted of newcomers in search of job opportunities around the area. Hostel residents differed from squatters and backyard shack dwellers as there was no control over who may or may not live in the hostels. These housed rural migrants and those employed but with low levels of income. These class dynamics and differences perpetuated fragmentation and social conflict among the residents of Bekkersdal, undermining social cohesion and solidarity among the community in the area. Thus, Khaba and Van Eeden (2016) and Van Eeden and Diedericks (2016) regard the situation in the Bekkersdal community (both the formal and informal area), as being a consequent of post-colonial time mining activities that created environmental harm and history of land settlement.

In the next subsection the socioeconomic and environmental factors of the Bekkersdal mining community are reviewed, with analysis presented on whether these factors heightened the disaster risks and vulnerability of the community in the area.

#### **4.4 THE SOCIO ECONOMIC AND ENVIRONMENTAL PROFILE OF BEKKERSDAL**

This section presents the socioeconomic and environmental profile of Bekkersdal in as far as it has a bearing on disaster risks and vulnerability. In this context, the socioeconomic environment has been defined as those social factors that have a bearing on disaster risks and vulnerability and include population growth, education

levels as well as the economic and environmental circumstances of households and individuals in Bekkersdal (WLM, 2011, WRDM, 2016). The RWC community in the Bekkersdal area has been faced by several socioeconomic and environmental risks that have heightened household vulnerability. Koen *et al.*, (2014) conducted a case study of Bekkersdal by exploring aspects that affected the wellbeing of the community. The general findings of the study indicated that the community of Bekkersdal has been negatively affected by high level of poverty, low levels of education, crime and unemployment as well as rapid population growth. The study also found out that over and above the general findings, the informal settlements of Bekkersdal have been engulfed by socioeconomic and environmental ills, such as illnesses, service delivery protests and several environmental risks (air pollution, dust, acid mine drainage due to mining activities, water pollution also caused by open canals, land pollution as a result of waste and littering). Further, the 2016/17 integrated development plan (IDP) of the RWC local municipality where Bekkersdal is located clearly indicate that the socioeconomic and environmental circumstances of the municipality had not improved but instead deteriorated as the municipality was facing several challenges, among them inadequate and ageing infrastructure, lack of refuse removal, illegal dumping, a culture of non-payment and vandalism of infrastructure, illegal protests, substance abuse, informal settlements, lack of housing, pollution, fragmented social development programmes, illegal connections to water and electricity lines, environmental risks (due to the area being in a dolomitic area, such as dust and pollution) and high levels of crime at 45/1000 compared to national average of 41/1000 respectively (WRDM, 2016/17, RWC, 2017/18).

The results of the study above concur with the Housing Development Agency report (2012) which showed that, generally, informal settlements across the country have similar features; inappropriate locations, poverty and vulnerability, social stress, lack basic services, and limited employment opportunities with disproportionate levels of violence and crime. As such, informal settlements are a threat to the environment as services are generally not available, there is no control over the location of the informal settlements (see Figure 18 below), as they often arise in sensitive environments such as dolomitic land, and water is not purified, which in turn has the potential to transmit diseases (WLM 2011/12, WRDM, 2016/17).



**Figure 18 The illegal occupation of land to build shacks by residents of Bekkersdal.**

Source: Citizen Newspaper, 2014

These socioeconomic and environmental issues described above (such as poverty, increased population, uncontrolled urbanisation and environmental degradation) have heightened vulnerability to disasters in local communities (COGTA, 2008). The South African Risk and Vulnerability Atlas (2005) notes that these socioeconomic and environmental ills as described above hamper efforts towards resilient communities. However, these socioeconomic and environmental factors are not unique to Bekkersdal, they have become a standard feature of many urban local townships in South Africa (Khaba & Van Eeden, 2016). Thus, South Africa's settlement structure is one that has been characterised by urban and rural sprawl, fragmentation, separation of land uses and income groups, and structural imbalances, all of which are typical of RWC (WLM, 2011/12, WRDM, 2016). Over the years, the mining sector has been on a steady decline (WRDM, 2016, WLM, 2008/09, WLM, 2011/12, Sosibo, 2013, Koen *et al.*, 2014, Ryke *et al.*, 2015, Van Eeden, 2011). The declining mining production and retrenchments in the area have negatively impacted the wellbeing of members of the Bekkersdal community who have become jobless. When their contracts ended, mineworkers who were employed temporarily erected shacks and began to reside in informal settlements nearby the mining areas, with the hope of finding employment again (Masondo 2011, Koen *et al.*, 2017, Van Eeden *et al.*, 2008).

The subsection below discusses some of the socioeconomic indicators of Bekkersdal, namely, employment, poverty, inequality and access to basic services. These indicators, among others, have a very large bearing on risk and vulnerability of households.

#### **4.4.1 Employment in Bekkersdal**

Data from the municipality in which Bekkersdal is located, the RWC local municipality, was used to construct a profile of the socioeconomic conditions of Bekkersdal. Figure 19 summarises the unemployment situation of Rand West City, including Bekkersdal. The average unemployment in Bekkersdal wards is 42%, which is higher than that of other wards in the RWC local municipality (MDB, 2018). In terms of employment, 28% of the labour force of RWC municipality is unemployed. This figure is slightly lower than the national average of 30%. Unemployment is prevalent among the youth (37%). Youth unemployment is particularly concerning in the country. Youth unemployment tends to drive many other vices, including crime and substance abuse, and in a mining area like Bekkersdal, many of the unemployed resort to illegal mining. In the RWC local municipality, those formally employed constitute only 15% of the labour force. Eighty-five percent of the labour force is in informal employment (MDB, 2018). The levels of unemployment in the municipality can also be attributed to the low levels of education, with 8.1% of the population reported as having had no schooling, whilst 8.3% completed primary school level, 21.1% had proceeded to matric and 1.9% had higher education (Stats SA, 2011).

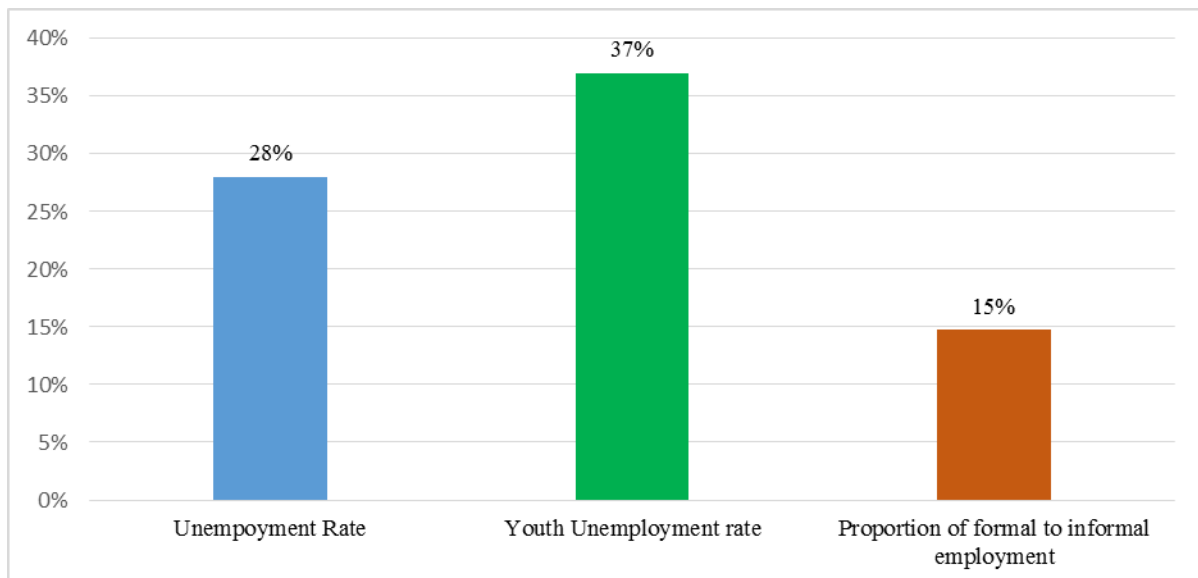


**Figure 19 Employment status of RWC Municipality**

Source: MDB 2018, RWC local municipality.

Many unemployed former mineworkers have also joined the ever-increasing informal activities (artisanal mining, small scale mining, quarrying) and reside in the informal settlements dotted around the mining areas (Masondo, 2011, Van Eeden & Diedericks, 2016). Since the late 1960s, informal sector populations have been expanding in leaps and bounds. In many instances there is no control over where informal settlements are located and, in most instances, they are located in vulnerable areas, which poses further risks to household health and safety. It is also worth noting that 27.8% of the population is reported as residing in the formal areas, while the rest of the population is located in informal areas (STATS SA, 2011).

#### **4.4.1.1 Employment by Sector**

It is not surprising that the largest proportion of workers in RWC local municipality where Bekkersdal is located are in the mining sector. About 33% of households in the municipality are employed in the mining, followed by those in Community and Social services and Wholesale and Retail Trade, both at 11.7% with Manufacturing accounting for 9.2 % of the employed (see Figure 20).

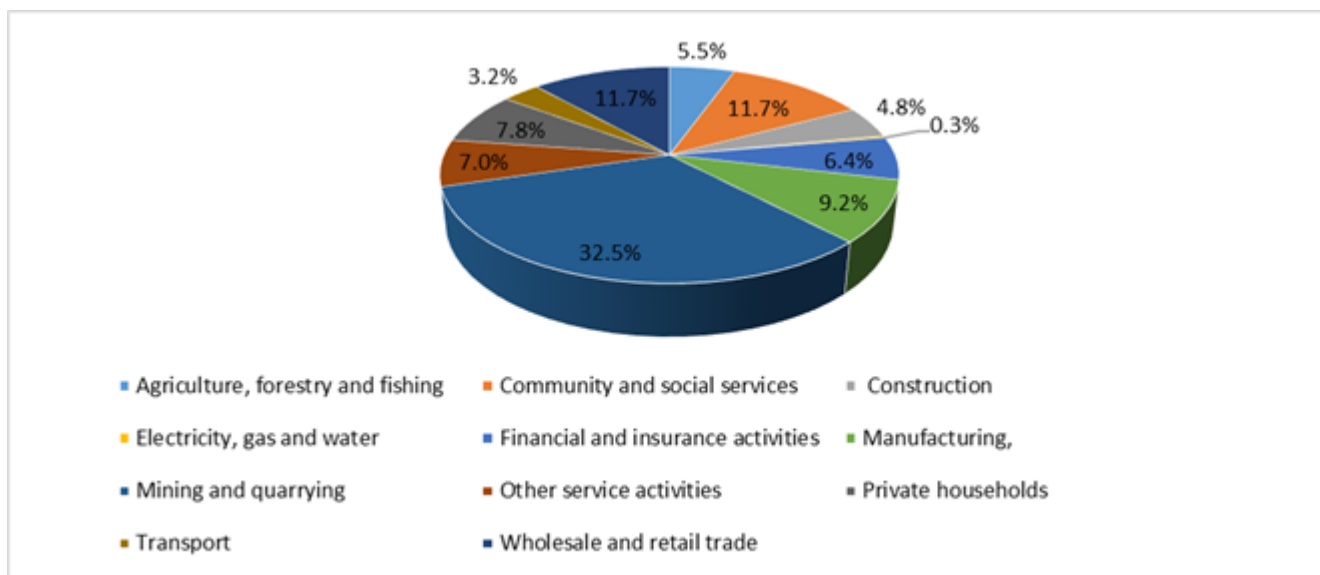


**Figure 20 Employment by sector**

Source: MDB 2018, RWC Local Municipality.

#### 4.4.2 Poverty in Rand West City municipality

Figure 21 provides a picture of income poverty for all municipalities that fall under WRDM by race. Overall, the incidence of poverty in Westonaria is 40%, second only to Merafong at 47%. Among Africans, poverty levels in Westonaria are the second highest (45%) with Merafong (55%). Besides unemployed people being generally vulnerable to many hazards, high levels of poverty, coupled with high levels of unemployment tend to exacerbate other problems such as inequality and crime (Cylex, 2003, WRDM, 2016/17).



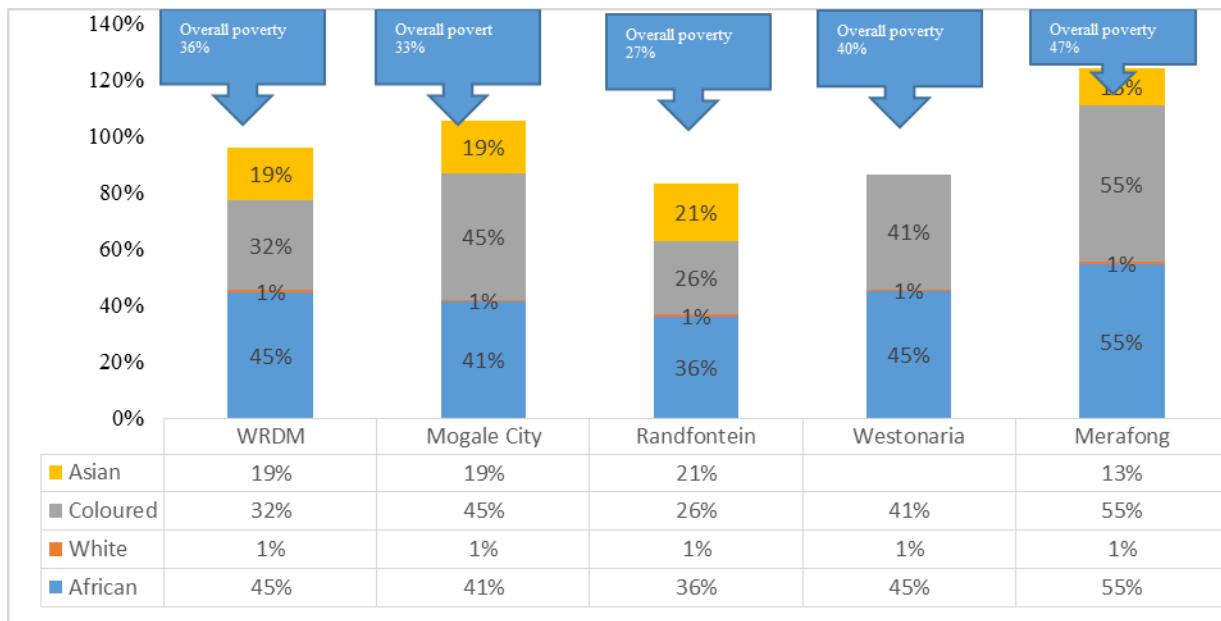


**Figure 21 Percentage of people in poverty in the WRDM**

Source: Global Insight 2017, Author's own calculations.

#### 4.4.3 Inequalities in the Rand West City Local Municipality

Inequality is another factor that has a bearing on household vulnerability and disaster risk. A society characterised by inequalities means that one segment of society is more at risk and more vulnerable than the other. Figure 22 below shows that the RWC municipality has a Gini Coefficient (a measure of inequality) of 0.716 which is 8 percentage points higher than the national average of 0.63. These figures indicate that RWC municipality has a more unequal community relative to the national average. This also confirms that the majority of households in the municipality wallow in poverty and are faced with limited access to resources.

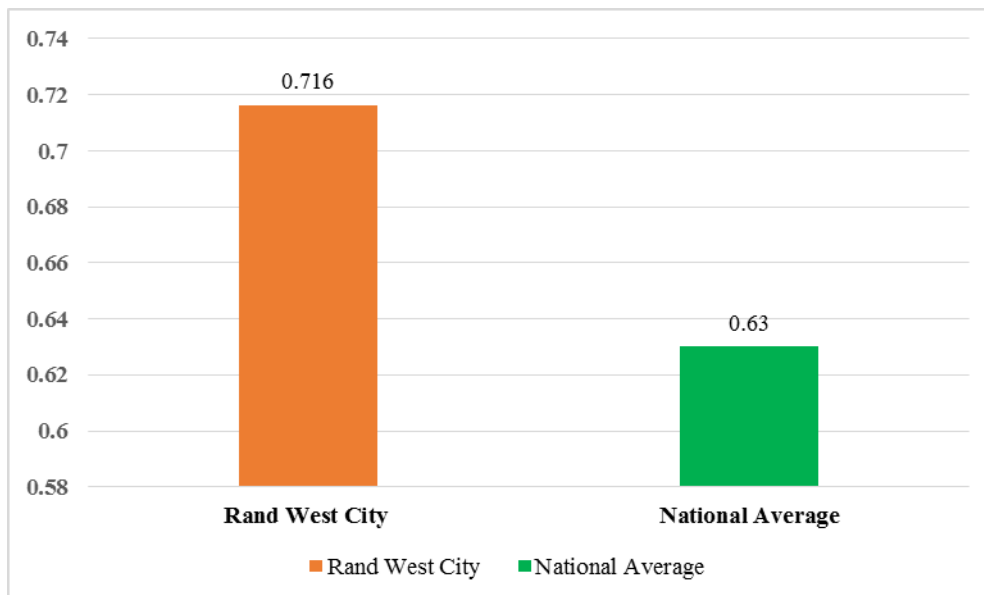


**Figure 22 Inequalities in the RWC Local Municipality**

Source: MDB Board2018, RWC Local Municipality.

#### 4.4.4 Access to Basic Services

Another socioeconomic indicator that has a bearing on vulnerability of households is access to basic services. Bekkersdal is one of the townships that experiences challenges such as lack of basic services, especially in informal settlements. Poor access to basic services has resulted in service delivery protests that are sometimes very violent (Van Eeden & Diedericks, 2016). Table 6 attempts to isolate access to basic services (electricity, sanitation, water, refuse) in Bekkersdal. As could be gleaned from Table 4.1, access to basic services in Bekkersdal is far lower than that found in other wards of the municipality. The plausible reason for this is that most of Bekkersdal is informal settlements. Households with inadequate access to electricity, inadequate access to toilets, inadequate access to water and refuse removal in Bekkersdal are on average estimated at 61%, 4%, 19% and 40%, respectively (see Table 6). Such low levels of access to basic services in Bekkersdal wards (wards 9-15) relative to other wards in the RWC local municipality indicates that the Bekkersdal community faces greater risks to disasters that emanate from mining activities in the areas and other hazards. Incidence of poverty and unemployment are extremely high in Bekkersdal. According to Stats SA census (2011) figures, 42% of the Bekkersdal population were unemployed and 61% of households were receiving less than R19 600 per annum.

**Table 6 A breakdown of households with inadequate access to the four key services, as well as inadequate access to income and unemployment in RWC Local Municipality**

|                                      |         |         |         |         |         |         |         |         | Bekkersdal Wards |         |         |         |         |         |         |         |         |
|--------------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|------------------|---------|---------|---------|---------|---------|---------|---------|---------|
| Ward no.<br>hhs                      | Ward 1  | Ward 2  | Ward 3  | Ward 4  | Ward 5  | Ward 6  | Ward 7  | Ward 8  | Ward 9           | Ward 10 | Ward 11 | Ward 12 | Ward 13 | Ward 14 | Ward 15 | Ward 16 | Average |
| HHs inadequate access to electricity | 36<br>% | 3<br>%  | 1<br>%  | 0<br>%  | 6<br>%  | 1<br>%  | 0<br>%  | 1<br>%  | 99<br>%          | 58<br>% | 98<br>% | 12<br>% | 1<br>%  | 99<br>% | 57<br>% | 41<br>% | 32<br>% |
| HHs inadequate access to toilets     | 17<br>% | 0<br>%  | 0<br>%  | 0<br>%  | 2<br>%  | 0<br>%  | 0<br>%  | 1<br>%  | 3<br>%           | 3<br>%  | 7<br>%  | 5<br>%  | 1<br>%  | 7<br>%  | 5<br>%  | 4<br>%  | 3<br>%  |
| HHs inadequate access to water       | 25<br>% | 1<br>%  | 0<br>%  | 0<br>%  | 7<br>%  | 1<br>%  | 0<br>%  | 0<br>%  | 27<br>%          | 18<br>% | 34<br>% | 1<br>%  | 0<br>%  | 36<br>% | 25<br>% | 13<br>% | 12<br>% |
| HHs inadequate access to refuse      | 56<br>% | 4<br>%  | 13<br>% | 1<br>%  | 27<br>% | 5<br>%  | 1<br>%  | 1<br>%  | 61<br>%          | 40<br>% | 47<br>% | 21<br>% | 14<br>% | 54<br>% | 38<br>% | 59<br>% | 28<br>% |
| HHs pa income <R19600                | 29<br>% | 13<br>% | 16<br>% | 21<br>% | 19<br>% | 23<br>% | 44<br>% | 49<br>% | 72<br>%          | 59<br>% | 73<br>% | 45<br>% | 45<br>% | 70<br>% | 60<br>% | 57<br>% | 43<br>% |
| Unemployment                         | 16<br>% | 16<br>% | 4<br>%  | 18<br>% | 15<br>% | 16<br>% | 41<br>% | 41<br>% | 44<br>%          | 40<br>% | 47<br>% | 33<br>% | 41<br>% | 49<br>% | 38<br>% | 28<br>% | 30<br>% |
| Inadequate to services               | 33<br>% | 2<br>%  | 4<br>%  | 0<br>%  | 10<br>% | 2<br>%  | 0<br>%  | 1<br>%  | 47<br>%          | 30<br>% | 46<br>% | 10<br>% | 4<br>%  | 49<br>% | 31<br>% | 29<br>% | 19<br>% |

Source: Municipal IQ (2014)

Further, the RWC municipality stated that while strides have been made in delivery of basic services such as water, sanitation and refuse removal, and electricity, non-delivery of these services to the informal settlements has been rife (RWC, 2017/18). As such, the high levels of unemployment and poverty, coupled by social unrest due to service delivery, had made the area of Bekkersdal very risky (Kritzing, 2017) and rendered the area what Khaba and Van Eeden (2016) labelled one of the most

“unstable, violent and controversial township(s)”, see Figure 23 below on violent protest by residents of Bekkersdal.



**Figure 23 Bekkersdal community violent protest due to illegal occupation of land owned by mining company in Bekkersdal**

Source: Mail and Guardian, 2014.

Van Eeden and Khaba (2016), argued that the rendering of inadequate services has been associated with outbreaks of violence. More than half of protests took place in informal settlements, especially in townships such as Bekkersdal (Lekaba, 2014), with Gauteng province regarded as the ‘protest capital’ (Matlala & Aboobaker, 2013, Lekaba, 2014). Over the years, Bekkersdal residents have become dissatisfied with population increase in the area and the downscaling of mining operations created political instability (Van Eeden & Khaba, 2016). Due to these service delivery protests Naidoo (2013), Poplak (2014), Sosibo (2013), Matlala and Aboobaker (2013), Municipal IQ (2013), and Van Eeden and Khaba (2016) have called the situation at Bekkersdal a “microcosm” of South Africa’s townships, “ground zero service delivery”, “dysfunctional”, “ (a) burning township”, “absolute deprivation”, and an “unstable, violent and controversial township...”.

The status of Bekkersdal can generally be attributed to, among other things, lack of basic services; overpowering sewerage, piled heaps of rubbish and health related diseases, streets filled with garbage dumps, undrained floodwater and sewerage, barricades of rocks turned roads into obstacles, unreliable municipal service and electrified informal settlements as well as public property being destroyed. The cost of public property destroyed amounted to millions of Rands (Lindeque, 2015, Sosibo, 2013). Not only that, shops and businesses in Bekkersdal have been looted and suspects arrested, and residents have demanded that the municipality be disbanded citing nepotism, corruption and maladministration (Whittles, 2015, Tau, 2011, Sosibo 2013).

The situation in Bekkersdal has in the past been regarded the worst disaster looming area, especially in informal settlements (Kubheka, 2018, Municipal IQ, 2014). For instance, the majority of households in the informal settlements of Bekkersdal do not have adequate basic services, with over 90% having no access to electricity and over 60% of households with no access to refuse removal (Municipal IQ, 2014). Fakir (2012), described Bekkersdal as a 'disaster and a dystopia', located in the richly gold deposit area, yet engraved by deprivation and dissatisfaction. The dire situation of Bekkersdal settlement highlights the vulnerability of households to their day to day socioeconomic and environmental ills (see Figure 24).

In 2016, Van Eeden and Diedericks, conducted a study on the availability or lack thereof of public service delivery and the impact this has on lives of people in the Bekkersdal informal settlements. The study found that 78% of households lack public service delivery in the area, which negatively affects their wellbeing, while 58% of Bekkersdal residents indicated that they were unhappy living in the informal settlements. Other factors that Bekkersdal informal settlement residents indicated as impacting on their lives negatively included the long wait for the RDP houses, living near dumping sites, littering and sewerage risks, and lack of basic services, especially water, electricity, and flush toilets. However, what could also be gleaned from the research is that vulnerable households in Bekkersdal do not necessarily view the goldmines as their biggest risk factor. They rather reflect their vulnerabilities more in terms of unemployment and lack of services, among others. The long-term risks and disasters arising from mining

activities which result in risks like water pollution seem to be somewhat remote and at best tolerated by the residents.



**Figure 24 Bekkersdal roads filled with sewerage and rocks**

Source: Sosibo, 2013.

The next subsection discusses the disaster risks in the mining community of Bekkersdal, which have not been addressed and as such has resulted in and heightened the vulnerability levels of households.

#### **4.5 THE DISASTER (MINING) RISKS AND VULNERABILITY IN BEKKERSDAL**

According to (Winde & Stoch, 2010) gold mining activities in the Wonderfonteinspruit (WFS), in the Westonaria town where Bekkersdal is located date back to over 120 years. Gold mining activities created employment opportunities and became the major source of income to the surrounding mining communities in the WFS, resulting in rapid urbanisation in the area. However, negative impacts related to mining activities have been recorded in the WFS. These include land degradation as a result of dewatering



which in turn forms dolomites and sinkholes, pollution of surface and underground water which affects general livelihoods of households in the area, as well as respiratory illnesses (Winde & Stoch 2010, Koen *et al.*, 2017). Work by Liefferink (2019) supports the above arguments and shows that the Witwatersrand has been mined for more than a century and pollution related to Witwatersrand mines poses several hazards to surrounding communities, such as dust and radiation, among others. The WFS is densely populated and the water in the area is used for recreation, spiritual rituals, domestic purposes, irrigation, grazing and drinking purposes. There is contamination of wetlands with radioactive dust and metals. High levels of acid mine drainage have been found in the Wonderfontein spruit catchment area, and long-term exposure to acid mine drainage in drinking water may lead to increased rates of cancer, decreased cognitive function and sub optimal neural development of the foetus, which can lead to child developmental disabilities (Liefferink, 2019).

Moshodi *et al.*, (2015) states that the West Rand District in Gauteng province is known to be underlain by extensive dolomite rock formations, exacerbated further by human induced activities such as ground water extraction, leakage from water pipes and sewerage. News24 (2011), reported that Gauteng authorities have been warned of an increasing risk of dolomitic sinkholes in Gauteng with damage caused to development and infrastructure estimated at a very conservative R1.5 billion. Also, in the townships and informal settlements, it has been found that leaking taps and burst pipes trigger dolomitic erosion which expands underground activities. In Westonaria, there are ever growing sinkholes. Tau (2011), argues that Bekkersdal is one of the areas built on dolomitic land. As such, various areas in Gauteng, which include parts of Bekkersdal, are on dolomite and have experienced sinkhole incidents. In some instances, households have been evacuated from their homes in Westonaria due to sinkholes appearing in their houses (see Figure 25).



**Figure 25 Site visit of dolomite in Westonaria**

Source: Tau (2011).

In South Africa, it has been estimated that 25 000 sinkholes have been identified and nearly half of the sinkholes are in Westonaria, where Bekkersdal is located, in the West Rand, Gauteng province (Kritzinger, 2017). It is estimated that about 64% of the municipal land in the WRDM where Bekkersdal is located remains unsuitable for housing due to dolomitic conditions and steep slopes (WRDM, 2013). The 2016 IDPs of the RWC municipality and Khaba and Van Eeden (2015) highlight that the underlying dolomitic conditions in the area have been the greatest restraining factor on development, resulting in high levels of densification. Large parts of the WRDM area are not suitable for development due to shallow mining resulting in development in the area being fragmented (WRDM, 2013, RWC, 2017/18). Koen *et al.*, (2014) and WRDM (2013) further state that the building of informal settlements on the dolomitic land in Bekkersdal makes the area very risky and vulnerable to disaster risks. Coetzee (2013) refers to the residents of the informal settlements of Bekkersdal as sitting on a disaster time bomb, as residents have settled on dolomite formations which could lead to loss of life due to sinkhole formations.

In the Gauteng province, approximately 1.6 million people reside nearby tailings dams (Winde *et al.*, 2019). In the Upper WFS in Bekkersdal informal settlements, households have been exposed to mining tailing dust and to polluted surface and ground water used for drinking and livelihood activities such as agricultural and fishing activities. Van



Eeden *et al.*, (2009) and SAHRC (2009), further argued that the abandonment and closure of mines, and abandoned mine tailings in the West and Far East Rand where Bekkersdal is located had worsened the negative environmental effects in the area with dust, water pollution and respiratory illnesses. There are also health and safety concerns related to the large pits from mining digging which have become breeding places for mosquitos during the rainy season, raising fears of malaria transmission. When these pits and trenches remain open, they become death traps and are a result of the disregard of compliance and safety measures related to rehabilitation of mine tailings. Wolmarans (2014) also cites spillages from pipes carrying metal-laden sludge onto public areas and into the WFS dam as mining companies do not abide by national environment management act provisions (see Figure 26).



**Figure 26 Wonderfonteinspruit Catchment Area: Contaminated water**

Source: Water Affairs and Forestry 2009.

Effects of acid mine drainage in the Upper WFS where households of the Bekkersdal informal settlements reside have been noted (Koen *et al.*, 2017). Liefferink and van Eeden (2010), describe the effects of acid mine drainage (toxic and radioactive mining waste materials) due to mining activities in the West Rand goldfields as the worst environmental injustice as it affects human health and households' livelihoods. Van Eeden *et al.*, (2008) further argues that acid mine drainage has been associated with

land degradation, polluted surface and groundwater resources. Exposure to the acid mine drainage results in illnesses such as cancer and skin infections and, as such, it is hazardous and exposes the people of WFS to vulnerability. According to the South African Human Rights Commission (2015) report, the Witwatersrand Goldfields, have rendered water quality poor with negative effects on people's health. The acid mine drainage is a result of the flooding of mine basins or the runoff from mine dumps. The flow of acid mine drainage into South Africa's surface and groundwater has negative impacts (Caincross *et al.*, 2013, Liefferink 2019) which include degradation of water quality, poisoning of food crops, endangerment of human health and the destruction of wildlife, ecosystems and infrastructure. Thus, acid mine drainage poses risk to the realisation of the rights to human health, wellbeing and dignity as enshrined in the Constitution. Figure 27 shows the occurrence of acid mine drainage in the West Rand.



**Figure 27 Acid Mine Drainage in the West Rand**

Source: South African Human Rights Commission (2015).

In the Witwatersrand Gold Fields region, there has been a growing threat of flooding of abandoned mines and the decanting of acid mine drainage into groundwater resources, which are used for agricultural and human consumption. According to Cairncross *et al.*, (2013), Liefferink (2019), Koen *et al.*, (2014), these high levels of acid mine drainage in the Wonderfontein spruit catchment area and long term exposure to acid mine drainage to drinking water may lead to increased rates of cancer, decreased cognitive function

and compromised neural development of the foetus which can lead to child developmental disabilities. Mine effluent has a negative impact on the quality of groundwater as well. Some communities use groundwater from boreholes. Such water is used in farming, for livestock and to irrigate crops, and for drinking purposes in informal settlements. Thus, the pollution of groundwater from mines poses a big threat to human health and other living organisms that depend on this water, including contamination of nearby wetlands with radioactive dust and metals.

Van Eeden (2011) noted that the Donaldson dam has high radioactivity levels which are harmful to health and wellbeing of communities that use its water. Van Eeden *et al.*, (2009) also noted that over the years, toxic and radioactive materials have originated from gold mines in the West Rand area and into the WFS catchment area. Bega (2018) added that 36 radiological hotspots were identified in the WFS catchment area. These were due to the flow of tainted runoff from its dumps into the WFS. When Winde (2009) assessed the quantification of uranium pollution in the WFS, where it was found that uranium in contact with underground water has been a source of waterborne pollution in the area. Thus, the discharged uranium polluted water from tailings deposits has become a major source of water pollution in the WFS. Also, Winde *et al.*, (2019) conducted a study of human exposure to uranium in relation to gold mining activities in the Witwatersrand basin, where Westonaria in West Rand is located. The results of the study found that there are higher levels of uranium concentration and exposure of households to the uranium effects is hazardous to health as it can cause cancer. In a nutshell, it can be deduced that from history and current events, that Bekkersdal township faces a number of challenges with potential to compound the vulnerability of the community (see Figure 28).



**Figure 28 Water use in Wonderfonteinspruit by residents of the Bekkersdal area in the polluted Donaldson Dam**

Source: DeCrom and Nealer (2017).

In a study conducted by Liefferink *et al.*, (2017) on water related challenges among the informal residents of Bekkersdal, it was found that water supply in the area has often been inadequate or not purified, giving rise to water borne diseases. In addition, it was found that the Donaldson dam in particular is highly polluted due to mining related discharges from surrounding areas. Information from a sample of 642 households in Bekkersdal found that water from the Donaldson dam had negative health effects to about 11.5% of sampled households (Liefferink *et al.*, 2017:437). Yet, the dam is used by the Bekkersdal community for baptisms, fishing and there are stalls close by where food is sold, and livestock also drink from the dam (Van Eeden, 2011). The distribution of the health hazards associated with the Donaldson dam water is shown in Figure 29 below. This water is used mainly by traditional healers (35.45%), unemployed residents (25.60%) and fishermen (23.01%) (Liefferink *et al.*, 2017).



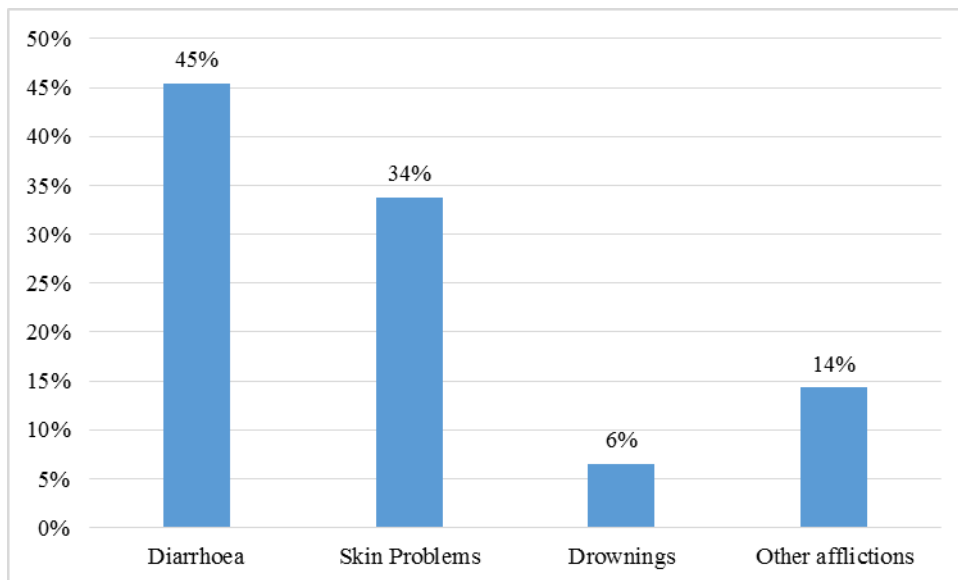


**Figure 29 Health Effects of water from the Donaldson Dam close to Bekkersdal**

Source: Liefferink *et al.*, (2017).

From the scholarly research reviewed so far it can be argued that mining activities drive, quite significantly, some of the challenges faced by the communities of Bekkersdal, in particular, and Rand West, in general. Mining activities are the single most important creator of disaster and vulnerability risks in the area. In other words, mining activities account has increased the risk profiles of households in Bekkersdal. In Bekkersdal the brittle dolomitic environment coupled with acid mine drainage, poses severe challenges to the households of this area. Communities are exposed to hazardous by-products and contamination that comes from gold mining runoff. As has been noted above, gold mining is the principal economic activity on the West Rand and it is the basis of the economy and socioeconomic development of the region (Ngcobo, 2008). The gold-mining industry is responsible for acid mine drainage which affects the environment by contaminating water and soil (Davie, 2011). The decanting of acid mining drainage on the surrounding areas has serious ecological effects, as it pollutes rivers and subsequently dams. It is a threat to humans, animals and general plant species that depend on this water. As noted by Pegg (2005), mining activities by their very nature involve toxic chemicals including those used in mining tailings dams. The dolomitic geological conditions of the area are associated with sinkholes which also have emerged from the mining history of the area. Sinkholes add to the risks that these communities face. They undermine the environment and water quality. Figure 30

summarises the main challenges facing the community. All these challenges are heavily linked to mining in the area.



**Figure 30 Summary of disaster risk challenges of Bekkersdal mining township**

Source: Author's summary.

#### **4.6 CONCLUSION**

The foregoing narrative profiles and contextualises Bekkersdal Township using multiple lenses. The analysis reviews the history of the present thesis' case study. It also gives an outline of the socioeconomic characteristics of the township. In addition, the Chapter discusses the township's disaster risk and vulnerability profiles.

Bekkersdal has a long history, dating back to 1945. The township owes its existence to mining. Mining has been the key driver of the Bekkersdal economy since then. The

abundant gold deposits that characterised the Bekkersdal of the 1940s and 1950s attracted many workers from within the country and the Southern African region. As the population increased, many workers could not find accommodation in the formal areas, and instead joined the ever-growing informal sector. Present day Bekkersdal has 70% of its population residing in informal settlements. The rapid growth of the informal sector has had its own challenges. Poverty and squalor became endemic in informal areas. Informal settlements of Bekkersdal also faced other challenges, including lack of basic services, lack of infrastructure, crime and widening deficits in health and education. The establishment of Bekkersdal as a mining town and the closure of some mines over the years have left a mining legacy of environmental degradation which has had a negative impact on the Bekkersdal community.

Bekkersdal is also located in a dolomitic landscape, making it prone to sinkhole formation. As noted in this Chapter, this has limited space for housing and development. Mining activities in the area have had other negative externalities as well. Acid mine drainage has posed many health challenges to the community of Bekkersdal. Acid mine drainage has deprived the community and livestock of clean water. The community has faced many other disasters, such as veld fires, flooding, drought and disease.

Taken together, the foregoing profiles highlight a number of variables that account for the disaster risk and vulnerability of the Bekkersdal community. A significant population of Bekkersdal suffers from acute levels of poverty, inequality, unemployment and limited access to basic services. All these factors potentially amplify the risks and compromise the vulnerability of the community of Bekkersdal. The next chapter discusses methods used to assess the risks and vulnerabilities of the Bekkersdal community.

## **CHAPTER 5**

### **RESEARCH METHODOLOGY**

#### **RODUCTION**

To reiterate, two questions that underpin this study: (i) What are the vulnerability levels of informal and formal households (individually and comparatively) in the Bekkersdal area of RWC? and (ii) What recommendations can be made with regard to the management of disaster risks and vulnerability of the households in the post-mining risk area? Chapter 5 therefore presents research techniques used to answer these two key questions. The methods described in this Chapter were used to collect and analyse data in the subsequent two chapters.

Therefore, present research followed a mixed method approach where a triangular design with a case study approach used to compared the vulnerability levels of households in both the formal and informal areas of Bekkersdal. The qualitative data obtained through the questionnaire was used to as gauge the vulnerability levels of Bekkersdal households to disaster risks, whilst the quantitative methods collected data from the questionnaire which was used for the estimation of vulnerability index and regression analysis. Further, the case study also enabled the systematic recording of qualitative and quantitative evidence as direct observation, with interviews being the main source of information. Thus, a discussion of the above is detailed in the sections of the study below.

#### **5.2 STUDY AREA/ LOCATION**

As alluded at in Chapter 1 of the thesis, (see section1.2 of this thesis), the Rand West City (RWC) local municipality located in the district of West Rand District Municipality was the focus of the case study (see Chapter 4 of the thesis on Figure 13), RWC local municipality, where Bekkersdal is located. As highlighted in the preceding chapters, Westonaria is a town in the Bekkersdal township, and it came into existence in the year 1945 as a result of gold mining activities in the area. The gold mining activities created employment opportunities and became the major source of income to the surrounding



mining communities, causing rapid urbanisation in the area. At the same time, mining activities also resulted in negative environmental impacts in the area, from as early as the 20<sup>th</sup> century (Van Eeden, 2006, Liefferink *et al.*, 2017). These included: land degradation as a result of dewatering, which in turn forms dolomites and sinkholes, pollution of surface and underground water in the area which affects general livelihoods of households, farmers and livestock, and acid mine drainage due to mine effluents in the area polluting the environment. Donaldson dam adjacent to the informal households is the source of water used for domestic consumption and other activities. The dam is known for its high radioactive levels which pose serious health risks such as that of respiratory illnesses (Winde & Stoch, 2010, Koen *et al.*, 2017, Van Eeden, 2009, Liefferink *et al.*, 2017).

Furthermore, urban growth in Westonaria due to industrial activities resulted in communities building shacks in places unsuitable for development such as old slime dams or near abandoned mining areas, exposing households to serious environmental risks such as radiation, dust and tailings. Also, what is unique to Bekkersdal households has been the decline in the mining sector due to falling production which has negatively impacted the general wellbeing of the households as they remain unemployed (Koen *et al.*, 2017, Van Eeden *et al.*, 2009). Closed and abandoned mines have also not been rehabilitated. At the same time, there are day-to-day challenges (poverty, poor standards of living, unemployment, unequal distribution of asset ownership, lack of access to resources, slow growth of the local economy, health related issues, service delivery protests, water pollution also caused by open canals, land pollution as a result of waste and littering) faced by the households of Bekkersdal township, which have generally become a norm in all townships across the country (COGTA, 2005, WRDM, 2017/18, RWC 2016/17, Koen *et al.*, 2014). Since the establishment of Bekkersdal as a mining town, the gradual closure of mines over the years, the socio economic and environmental challenges have left the town and its residents in a dire state which has intensified their vulnerability to any form of disaster risks that they experience now or might experience in the future.

### 5.3 RESEARCH METHODOLOGY

The study forms part of a National Research Foundation (NRF) funded integrative multidisciplinary (IMD) project directed towards disaster risk studies on communities in surrounding mining areas launched in 2013 (see Appendix 3). The institution leading the research was the North-West University (NWU), with the University of South Africa and the Tshwane University of Technology (TUT) as participating institutions. The IMD research project aimed at investigating the eco-health and wellbeing status of mining communities. Bekkersdal was selected as the site for a case study.

The IMD research model focused on gathering research inputs from various disciplines and communicating the research outcomes in ways other than the traditional mono-discipline way of thinking (Ryke *et al.*, 2015). Relevant disciplines in the project included the built environment (services, housing), the natural environment and the wellbeing environment (financial, social, emotional and psychological) (Ryke *et al.*, 2015). As noted by Van Eeden during the pilot phase of the study (2011), the motivation for starting an “integrative multidisciplinary research project was to establish whether several disciplines had the potential to collectively engage in rigorous integrative research”. For a comprehensive description of the evolution and nature of the project, the reader is also referred to Van Eeden (2011), Van Eeden and Diedericks (2016), Van Eeden and Khaba (2016), Van Eeden 2014, Ryke *et al.*, (2015), Liefferink (2017), Koen *et al.*, (2017), Liefferink (2015). The integrative multidisciplinary research project started with human and social science disciplines leading the process, and gradually expanded to involve applied sciences such as sociology, law, economy, public administration, and geography. Other applied sciences disciplines also involved were disaster risk studies, social work and ecotourism (Van Eeden, 2014:1-21).

In 2013, when the IMD project commenced, a baseline survey multidisciplinary questionnaire was developed by the IMD team and administered to households by trained fieldworkers from the Bekkersdal area. By 2017 the IMD project had been through both qualitative and quantitative data collection, to examine a wide range of issues in and around Bekkersdal, including eco-health and wellbeing of residents, water related challenges, service delivery the assessment of the wellbeing of the Bekkersdal community. Against the context of the IMD project, this research on the disaster risks

comprising the case study in Bekkersdal started in 2015. The aim was to ensure that the study uses both qualitative and quantitative approaches, as encapsulated in a questionnaire, with a focus on investigating vulnerability to disaster risks of both the formal and informal household in the Bekkersdal mining community. In the subsection to follow, the study area/location of Bekkersdal is discussed.

### **5.3.1 Sampling**

Sampling has been defined as a subset of a population that being observed to make inferences about the nature of the general population (Taherdoost, 2016, Rahi, 2017). In the main, sampling is chosen for its amenability to the drawing of generalisations. In this study, a sample of 1 000 households was selected from the formal and informal population of the Bekkersdal area, to establish the levels of vulnerability to disasters risks in the mining community. A multi-staged sampling procedure was used in the study. Firstly, purposive sampling was adopted to select the study area: Bekkersdal, and the wards of formal and informal settlements within Bekkersdal. The wards were selected based on accessibility and proximity to the researcher. Secondly, households within each ward, were randomly selected to make sure that everyone in the sampling frame had an equal chance of being selected. This offered an opportunity for all households, both informal and formal, to be selected. Using random number tables, the researcher generated random numbers which meant every Thirdly, households were interviewed. On the one hand, random sampling was adopted as it reduced chances of bias and enabled the sample to be highly representative of the population. On the other hand, random sampling has several weaknesses, including that it was difficult to access every third household and it was expensive and time consuming to contact some households. In addition to households, government officials were selected as key informants through purposive sampling. Purposive sampling was used to target officials as it was accepted that they would have more insight on their wards, some managerial expertise and would be knowledgeable on disasters in the Bekkersdal and be able to contribute appropriate insight to evidence on disasters risks in the study area.

### **5.3.2 Data Collection Methods**

Unlike other studies within the IMD umbrella project (see Appendix 3), this project focussed on the vulnerability of households to disaster risk in the mining community of

Bekkersdal. The data collection exercise was therefore aimed at gathering information that would assist in determining the vulnerability of the Bekkersdal community to disaster risks, given that the area is surrounded by mining activities (see Appendix 1). The information collected, would also assist in comparing informal and formal household vulnerability due to disaster risks in the area. Furthermore, a questionnaire was prepared specifically for officials at the district municipality responsible for management of disaster risks in Bekkersdal at Westonaria, as it falls under their ambit (see Appendix 2).

Before the actual data collection was undertaken, the following key steps were followed:

- The researcher conducting this research filled in the declaration form on research ethics indicating that North-West University research ethics will be followed (see ethics number: FH-BE-2013-0014 and Appendix 5). In the questionnaire, there were questions that required cooperation with, among others, government officials and community leaders so as to get access to individuals or groups, including recording of names of respondents who participated in the research exercise so that if there is a need, then follow up interviews can be undertaken.
- There was pre-contact with gate keepers, who are the local authority representatives to get their permission, buy-in and to introduce the objectives and expected outcomes of the study. The target audience were officials in the district municipality responsible for disaster risks in the RWC local municipality in Bekkersdal.
- In terms of collection of data from households, 15 field workers, all from the Bekkersdal area were selected and trained in the area, and they participated as supportive members of the IMD project. The field workers were selected based on their residency in the area, knowledge of the area, their familiarity with the languages spoken, as well as their ability to translate English into these main languages of the area. Workshops were held with field workers to familiarise them with the objectives of the study and to give the fieldworkers an opportunity to seek clarity pertaining to the project and the questionnaire they were to administer. In addition, the field workers were remunerated as a way to create jobs and facilitate involvement with research in their own community.

- The questionnaire was subsequently piloted in 15 Bekkersdal households, to ascertain the questionnaire would generate the required information, and in so doing, gather information that is reliable and valid. The information from the pilot was then subjected to some mini data analysis to gauge the reliability and validity of the analytical procedure. Problems in the questionnaire were identified and rectified. The piloting culminated in a review and modifications of the questionnaire in preparation for the large scale roll out of the survey.

For collection of the data, the questionnaire was crafted and administered through a survey. There were two groups targeted for the case study. The first respondents were households of Bekkersdal, in the formal and informal settlements, and the second respondents were the disaster practitioners/ officials of WRDM, who are responsible for the management of disaster risks in the Bekkersdal community of the RWC local municipality. In relation to the first and second respondents, collection of data was structured as follows; the questionnaire was used as a collection method for primary survey data. There were 16 questions (with subsections) to be administered by the 15 fieldworkers to the households in the formal and informal settlements of the Bekkersdal community. The 15 field workers interviewed a total of 1 000 households (formal and informal) over a three to four-week period. Out of the 1 000 households, 996 households responded. The interviews relied mainly on a 10 page questionnaire comprising of both structured and non-structured questions (representing the quantitative and qualitative approaches, respectively, (see appendix 1 on household vulnerability questionnaire ) on household vulnerability questionnaire).The questions in the questionnaire were mainly informed by the literature reviewed as outlined in Chapters 2 and 3 of the study, with a focus on disasters, disaster risks, and vulnerability of households (formal and informal) to the disasters risks (including mining related risks).

Similar approach to the administration of the household questionnaire was followed, except that the Key informants were reached through a similar approach to the administration of the household questionnaire as discussed above. The questionnaire was administered by the researcher to disaster practitioners responsible for management of disaster risks in the RWC local municipality where Bekkersdal is

located. The questionnaire comprised a 6-page questionnaire (with subsections) covering both qualitative and quantitative data (see attached questionnaire in Appendix 2, disaster practitioner questionnaire) so as to get insight into perspectives of the disaster practitioners towards disaster risks in the area and how they address and manage the disaster risks to households in their municipal area.

### **5.3.3 Mixed Method Analysis**

As noted above in the introduction section, the analysis in this chapter was underpinned by mixed method research techniques, which is a combination of both qualitative and quantitative research methods. Several scholars justify the use of a mixed methods approaches to triangulate different techniques so as to increase the validity of the results through the convergence, corroboration and the correspondence of results (Du Plessis & Majam, 2010, Amalki, 2016, Creswell, 2014, Johnson & Schoenboem, 2017). The mixed method approach augurs well for both close and open-ended questions found in the questionnaire. One of the advantages of using the mixed methods approach is that it allows the interaction of numbers and words in the analysis, while at the same time combining inductive and deductive thinking (Du Plessis & Majam, 2010, Cropley, 2019). Thus, the mixed research methodology (qualitative and quantitative) was adopted, with a case-study approach used to evaluate the vulnerability of the formal and informal Bekkersdal households to disaster risks in an environmentally, economically and socially vulnerable community.

### **5.3.4 Quantitative Data Analysis**

The aim of empirical research through a questionnaire is to, among other things, gather 'evidence' as information, where data is collected and analysed numerically (Jarbandhan & De Wet Schutte 2006, Goundar, 2012). Therefore, in this instance, the quantitative approach was applied for primary data collection. The questionnaire was used as a mechanism to collect data on disaster risks in the area through a survey of the households (formal and the informal) of Bekkersdal. To achieve this, as alluded above, quantitative analysis relied mainly on the use of structured and closed ended questions. The questions posed, were guided by literature reviewed in the preceding chapters about the importance of these variables towards vulnerability of households.

The aim of the quantitative method is to collect and analyse data numerically (Goundar, 2012, Cropley, 2019) as it seeks to establish the cause and effect relationship among the variables.

In terms of the quantitative analysis aspect of the study, three phases were undertaken. *Firstly*, the quantitative analysis entailed computing descriptive measures in order to fully understand the sample or data. The means, frequencies or proportions were calculated for demographic information. Descriptive statistics help provide summaries of the sample and to visualise the sample, and, above all, they form the basis for quantitative analysis. Descriptive analysis provides a feel of the distributional patterns of the sample under scrutiny. For example, instead of listing the ages of all our respondents, a computed mean (average) age of the sample was used, so as to determine how old the household heads in our sample were. It may not be prudent to list all females in the sample but providing a proportion of females in the sample may benefit the reader in understanding the gender dimensions of the Bekkersdal populations. Even as we discuss the extent of vulnerability in subsequent chapters, an understanding of the number of women in Bekkersdal is critical for such an analysis. This phase therefore involved estimating the means and proportions. Proportions were computed for variables such as gender, education levels, residential status (formal vs informal), language spoken, employment status and housing type.

Thus, *first phase* of the quantitative analysis entailed structured or close-ended questions were of four types and mainly aimed at gaining insight on households' views on the vulnerability risk levels they faced as per the below:

- Single response questions with nominal or ordinal categories (such as; Please tick "Yes", "No" or "I don't know" in the appropriate box;
- Multiple responses (for example, has the household/community been affected by any of the following risks in the last 3 years? Please tick appropriate box);
- Scaled questions (such as on a scale of 1-3, in which 1= High vulnerability<sup>8</sup>, 2= Medium vulnerability; 3 = Low vulnerability<sup>9</sup>. Please tick and rank vulnerability of the groups;

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<sup>8</sup> *High vulnerability* = households that are in critical state and would need expert assistance to recover from the impacts of shocks; *Medium Vulnerability* = households that require some level of external

- Binary or dichotomous questions mainly used to solicit demographic information such as gender (male or female) and type of household (informal vs informal).

See examples below;

**Does the household own any of the following assets? Please tick the appropriate box.**

| Assets          | Yes | No | Don't Know |
|-----------------|-----|----|------------|
| Land            |     |    |            |
| Farm            |     |    |            |
| Mine            |     |    |            |
| Livestock       |     |    |            |
| House/ Property |     |    |            |
| Business        |     |    |            |

**Has the household/community been affected by any of the following risks in the last 3 years? Please tick appropriate box), see example below;**

| Disaster Events |                                                                    | 1. Very Significant | 2. Significant | 3. Not significant |
|-----------------|--------------------------------------------------------------------|---------------------|----------------|--------------------|
| <b>a</b>        | Drought                                                            |                     |                |                    |
| <b>b</b>        | Sinkholes                                                          |                     |                |                    |
| <b>c</b>        | Windstorms                                                         |                     |                |                    |
| <b>d</b>        | Earthquake                                                         |                     |                |                    |
| <b>e</b>        | Mining related incidents                                           |                     |                |                    |
| <b>f</b>        | Flooding                                                           |                     |                |                    |
| <b>g</b>        | Fire                                                               |                     |                |                    |
| <b>h</b>        | Social unrest (e.g. xenophobia attacks, service delivery protests) |                     |                |                    |
| <b>i</b>        | Health outbreaks (e.g. cholera, malaria)                           |                     |                |                    |

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assistance to overcome the given shock; *Low vulnerability*= households that can adjust to given shock without needing significant external support.



**Scaled questions (on a scale of 1-3, in which 1= High vulnerability<sup>10</sup>, 2= Medium vulnerability; 3 = Low vulnerability<sup>11</sup>. Please tick and rank vulnerability of the groups below);**

| Vulnerable groups |                 | 1 | 2 | 3 |
|-------------------|-----------------|---|---|---|
| <b>a</b>          | Children        |   |   |   |
| <b>b</b>          | Women           |   |   |   |
| <b>c</b>          | Men             |   |   |   |
| <b>d</b>          | Elderly people  |   |   |   |
| <b>e</b>          | Disabled people |   |   |   |
| <b>f</b>          | Immigrants      |   |   |   |

Structured questions have two main advantages (Sesay, 2012: 77-78): They require less thinking or reasoning on the part of the respondent and thus generally lead to better data accuracy and higher response rates. For the researcher, they are easy to code and analyse.

However, structured questions have some drawbacks. For instance, answers may not reflect the true feelings of respondents. If the questionnaire is poorly designed, and options do not cover all possible answers, then conclusions arrived at may be misleading. These challenges were ameliorated by pre-testing the questionnaire before the actual interviews begin. This was achieved in the study through pilot testing.

Likewise, with the disaster practitioner questionnaire; the quantitative analysis followed the descriptive analysis approach, where there were closed ended and structured questions. See examples below;

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<sup>10</sup> *High vulnerability* = households that are in critical state and would need expert assistance to recover from the impacts of shocks; *Medium Vulnerability* = households that require some level of external assistance to overcome the given shock; *Low vulnerability*= households that can adjust to given shock without needing significant external support.

**Are these Disaster Preparedness and Prevention (Mitigation) Measures indicated above integrated in the Development Plans (IDP's) of the Municipality?**

| Yes                                                              | No                                                                  |
|------------------------------------------------------------------|---------------------------------------------------------------------|
| If yes, please state reasons why you have adopted these measures | If no, please state reasons why you have not adopted these measures |
|                                                                  |                                                                     |

**Indicate type/s of measures are used by West Rand District (Bekkersdal, in the Westonaria Local Municipality) to adapt to disaster risks/impacts. Please tick appropriate box;**

| Response and Recovery Measures |                                                                                                      | Yes | No | Don't know |
|--------------------------------|------------------------------------------------------------------------------------------------------|-----|----|------------|
| <b>a</b>                       | Predetermined evacuation plans                                                                       |     |    |            |
| <b>b</b>                       | Disaster information dissemination                                                                   |     |    |            |
| <b>c</b>                       | Emergency response plans                                                                             |     |    |            |
| <b>d</b>                       | Early warning systems in place                                                                       |     |    |            |
| <b>e</b>                       | Community disaster risk practitioners                                                                |     |    |            |
| <b>f</b>                       | Risk assessment                                                                                      |     |    |            |
| <b>g</b>                       | Creation and provision of relief measures:<br>1. Shelters<br>2. Food<br>3. Medical attention         |     |    |            |
| <b>h</b>                       | Rehabilitation or replacement of assets:<br>1. Infrastructure services<br>2. Subsidisation of houses |     |    |            |

Thus, the quantitative element of the study enabled quantification of the disaster risk vulnerability levels of the formal and informal households in a brittle mining area. For the mixed method approach, questions were based on literature reviewed in Chapters 2 and 3 respectively, thus they were a mixture of the following:

- Personal information: gender makeup of household, marital status, employment and health status, type of household and housing structure;
- Socioeconomic indicators: age, sex, household size and income level, assets and savings, ethnicity and civil society;
- Environmental indicators: floods, fires, drought, mining-related risks and activities;
- Physical indicators: type of housing, access to water, sanitation, electricity, roads, transport facilities;
- Capacity indicators: early warning detections in place, availability of disaster mitigation measures in place, community awareness, programmes and projects implemented by government and other disaster practitioners, community measures in place (including answering the research questions under study);
- Households and disaster practitioner views and perceptions on disaster risks in the area, how they have been managed and how they ought to be managed.

Once the data was collected, information from structured and close ended questions was cleaned and coded. (Jones & Hidiroglou, 2013). A coding scheme was drafted to enable data to be entered directly from the questionnaire into the database. The cleaning process entailed identification and removal of outliers, that is, revisiting original questionnaires to address obvious flaws in data entries. Like in any survey, there were missing variables, as some of the respondents did not answer the questions. As such, questionnaires with many missing data were removed, but questionnaires with a small proportion of missing values were retained if retaining such questionnaires would not affect the representativeness of the findings. The coded information (that is, process of converting questionnaire data into meaningful categories to facilitate analysis) was organised and stored in Excel software. Excel was also used for computing descriptive statistics. For more sophisticated analysis, (econometric modelling of vulnerability determinants), the STATA software package was used.

### 5.3.4.1 Estimation of the Vulnerability Index

The *second phase* of the quantitative analysis involved estimating the extent of disaster vulnerability using the vulnerability index as suggested in Chapter 3 on empirical literature. Hence the study adopted the FANRPAN Household Vulnerability Index (HVI) as the main framework for analysing vulnerability. The HVI is a statistical tool used to quantify household vulnerability and it operationalises the Sustainable Livelihoods framework for analysing vulnerability. The framework emphasises the point that livelihoods of households are sustainable when they are able to cope with and “recover from stresses and shocks, and maintain or enhance their capabilities and assets, while not undermining the natural resource base”. This framework assumes that when a household or individual is endowed with more assets, it would be less vulnerable to disaster events. Conversely, a household with less assets/capitals is vulnerable to disasters. As noted elsewhere in this thesis (refer to Chapter 3 of the thesis) a household’s livelihood is generally influenced by five assets or capitals;

- *Human capital* - Disaster impacts on household demographic structure, that is. size and composition, and the mobility of household members;
- *Natural capital* - Disaster effects on the environment, such as the environmental degradation and access to natural capital;
- *Physical capital* - Disaster effects on changes in household physical assets, access to extension services and changes in optimal farm household production;
- *Financial capital* - Disasters effects on household financial assets, investment choices, household income and expenditure and market access;
- *Social capital* - Disaster effects on family social networks in terms of support, and inter and intra-relationships with government, community and other relatives.

Using the five capitals, the following formula was applied to assess vulnerability for each investigated household. The vulnerability index is generated by summing up the aggregate scores for various capitals divided by the total number of individual capitals:

$$\text{i). Vulnerability Index (VI)} = \frac{\text{Human Capital} + \text{Natural Capital} + \text{Physical Capital} + \text{Fiancial Capital} + \text{Social Capital}}{\text{Total number of capitals}}$$

All 5 capitals will have the same weight. Each capital is represented by some proxy indicator. In this study the parameters were categorized as follows:

- *Human capital* - Level of education of household head.
- *Natural capita l* - Household experience with environment hazard (fire, drought).
- *Physical capital* - Value of household physical assets (house).
- *Financial capital* - Household head's income (salary or grants) or expenditure value per month.
- *Social capital* - Household membership to social networks, such as member of stokvel, *omasingcwabisane* (funeral plans).

These 5 capitals were then used to quantify each individual's vulnerability index. To operationalise the 5 capitals, proxies (see Table 7 below) from the questionnaire were used to capture the above dimensions of capitals. Proxies used were only those of the household head. The following variables were used to operationalise the above five capitals:

**Table 7 Vulnerability Dimensions and Proxies Used**

| <b>Vulnerability Dimension</b> | <b>Proxy</b>                 |
|--------------------------------|------------------------------|
| <b>Human capital (HK)</b>      | Level of education (LE)      |
| <b>Financial Capital (FC)</b>  | Salary earned (SE)           |
| <b>Physical Capital (PC)</b>   | Livestock ownership (LO)     |
| <b>Social Capital (SC)</b>     | Social club membership (SCM) |
| <b>Natural capital (NC)</b>    | Land ownership (LAO)         |

The above indicators/proxies were selected on the basis of availability of data, and personal judgement of the functional relationship of the impact of the indicator on household vulnerability. The construction of the VI consisted of the following steps:

- *Normalisation of indicators:* As the above proxies are in different units and scales, the indicators were normalised to generate figures free from units as well as standardisation of the values of the indicators. The normalisation technique

follows that of UNDP's Human Development Index (UNDP, 2006). The normalised indicators lie between 0 and 1. The way a variable is normalised depends critically on the functional relationship between the indicator and vulnerability. In fact, two possible relationships can be identified.

- *Vulnerability increases with the increase in the value of the indicator variable:* In this case the indicator/proxy has an increasing functional relationship with vulnerability, or put differently, an increase in the indicator variable increases household vulnerability. A good example of such an indicator is rainfall for an informal sector community. An increase in rainfall increases the vulnerability of a community in the informal sector. When faced with such functional relationships, normalisation is carried out using the following formula (1).

$$x_i = \frac{X_i - \text{Min}(X_i)}{\text{Max}(X_i) - \text{Min}(X_i)} \quad \dots\dots\dots 1$$

Where X represents vulnerability indicator for individual *i*.

From the above formula, it is obvious that the normalisation score will lie between 0 and 1, whereby the value of 1 corresponds to maximum vulnerability and 0, the least.

- *Vulnerability increases with the decrease in the value of the indicator variable:* A good example is the education variable. A higher level of education implies lower vulnerability. Thus we can say that education has a decreasing functional relationship with vulnerability. For this case the normalised score is calculated using the following formula (2).

$$x_i = \frac{\text{Max}(X_i) - X_i}{\text{Max}(X_i) - \text{Min}(X_i)} \quad \dots\dots\dots 2$$

The proxies selected, fall into the second functional relationship and thus are normalised using the second formula.

### **The Vulnerability Index: (VI)**

The VI was computed by averaging the normalised scores of the five indicators of capitals. The following equation was adopted (3). It was also assumed that the 5 capitals carry the same weight as there was no basis, whether in theory or practice to place more weight on some variables and not others.

$$VI_i = \frac{\sum x_i}{K} \dots \dots \dots 3$$

Where *VI* is the vulnerability Index and *K* is the number of vulnerability indicators. From equation 3, the main sources of vulnerability were then adopted as in equation 4.

$$VI = \frac{NC + PC + FC + SC + HK}{K} \dots \dots \dots 4$$

Finally, to construct the VI, the five vulnerability dimensions were substituted by the above proxies as follows:

$$VI_i = \frac{LAO_i + LO_i + SE_i + SCM_i + LE_i}{5} \dots \dots \dots 5$$

Using the vulnerability index scores and following FANRPAN (2014) and Ncube *et al.* (2016), household heads were classified into three vulnerability categories. These ranged from highly vulnerable to very low vulnerability, (see Table 8 below). The sample was divided into 3 categories and equal interval classification (constant class intervals) was adopted. In this classification method, each category contains an equal data interval. To get data intervals, the data range (highest data value minus lowest data value) was divided by the number of classes, which is three in this case. The formula for classifying the intervals is:

$$\frac{\text{Range of data}}{\text{umber of classes}} = \frac{(\text{Highest Vulnerability Score} - \text{Lowest Vulnerability Score})}{\text{Number of classes}} \dots \dots \dots 6$$

After estimating the class interval, it was added to the lowest score first, then as many times as necessary in order to reveal the number of the predefined classes.

**Table 8 Household vulnerability status**

| <b>Vulnerability category</b> | <b>HVI value range</b> | <b>Situation of household</b>                                                                                                        |
|-------------------------------|------------------------|--------------------------------------------------------------------------------------------------------------------------------------|
| <b>Lowly Vulnerable</b>       | 0 - 49                 | Households that are coping and when in a vulnerable situation, they are able to cope.                                                |
| <b>Moderately Vulnerable</b>  | 49.1 - 61              | When hit hard by a shock, the household needs urgent but temporary external assistance for it to recover.                            |
| <b>Highly Vulnerable</b>      | 61.1 - 73              | Emergency level household-the equivalent of an intensive care situation-could be resuscitated only with the best possible expertise. |

#### **5.3.4.2 Explaining Vulnerability: Regression**

The *third and final phase* of the quantitative data analysis method involved designing a method to explain vulnerability. This involved isolating factors responsible for vulnerability. A simple ordinary least squares (OLS) regression approach was adopted. The vulnerability index was used as the dependent variable, while a number of variables were included as independent variables. The model estimated took the following form:

$$HVI = f(X)$$

Where *HVI* is household (H) vulnerability index and *X* refers to explanatory variables that include household head's level of education, age, marital status, gender, infrastructure (represented by access to electricity), asset ownership, access to social networks and access to basic services (represented by access to sanitation).



This model can be fully presented as:

$$HVI_i = \beta_0 + \beta_1 \text{HH head's level of education} + \beta_2 \text{HH age} + \beta_3 \text{Marital status} + \beta_4 \text{HH's gender} + \beta_5 \text{infrastructure} + \beta_6 \text{asset ownership} + \beta_7 \text{Access to social networks} + \beta_8 \text{Access to basic services} + \varepsilon_i$$

Where,  $i$  represents individual households in the sample,  $\beta_0$  is the intercept,  $\beta_1$  to  $\beta_8$  are the parameters/coefficients to be estimated, and  $\varepsilon$  is the usual error term.

To test the significance, credibility and validity of the different relationships in the above regression model, F statistics, R-squared and t-statistics were calculated. The F statistic simply tests whether the model estimated fits the data well. It is used to compare the fitness of different models. The F statistic tests the null hypothesis that none of the independent variables fits the data well, against the alternative hypothesis that all the variables fit the model well. To assess the F-statistic we check the magnitude of the probability value of the F-statistic. Generally, when the probability value is close to zero, it means the model is a good fit and supports the null hypothesis and a large probability value means the alternative hypothesis is supported, or none of the parameters is significant.

The R-squared tells a different story to the F-statistic. However, the difference is that the R-squared ( $R^2$ ) is about the proportion of the dependent variable explained by the independent variables. It measures the strength of the relationship between the dependent and the independent variables or the credibility or reliability of the model. This is done on a scale between 0 - 100%. In simplistic terms;  $R^2$  of zero means the independent variables are not explaining the dependent variables and if closer to 100% it means the independent variables significantly explain the dependent variables. So, the  $R^2$  must be used in conjunction with other tests of significance. One test used in this case to evaluate the significance of the variables is the t-test. The t-test is calculated by dividing the coefficient by the standard error. So, reporting a t-test or standard error is one and the same thing. The t-tests evaluates the significance of one term, holding others constant. A t-test tests the null hypothesis that a variable is significant against an alternative that it not significant. If the absolute value of the t-test is larger than the critical value found in a t-test table, then the independent variable in question

significantly explains the dependent variable. The degree of significance depends on how large the absolute value of the t-statistics is. For example, the rule of thumb is that a t-value of 2 means the variable is significant at 5% statistical level. A value between 0.72 and 2 means some weaker level of significance- at 10%.

In Chapters 6 and 7 these key statistics will be used and elaborated further to explain the significance, reliability and credibility of the models, as well as the significance of each of the independent variables.

### **5.3.5 Qualitative Data Analysis**

In order to gather knowledge that was not there before, thereby “gaining new insight” (Goundar, 2012), qualitative analysis should be used. The qualitative aspect of the research was used to elicit ‘real life context’ of the formal and informal households of Bekkersdal in relation to disaster risks in the area that, in turn, expose their vulnerability levels. To understand the behaviour of households, the researcher utilised one of the key advantages of using qualitative research, that is, it enables the understanding and eliciting of insight into the underlying factors behind human behaviour that cannot be possibly captured by the quantitative research. Scholars argue that the purpose of qualitative research technique is to acquire an ‘insider view of reality’ (Mouton, 2007; Cropley, 2019). Similarly, in the case of the present study, qualitative analysis allowed the researcher to get an insider perspective of the vulnerability to disaster risks of households (formal and informal) in the Bekkersdal mining community. As highlighted above, the qualitative questionnaire had unstructured and open-ended questionnaires as per the below (also see Appendix 1):

**What is the household perception of security in the Bekkersdal Community?  
Please state below**

**a**

**b**

**Any social structure in place for disaster events/ to deal with disaster events in Bekkersdal and do they serve their purpose? Please state below**

**a**

**b**

In addition, other elements of the qualitative data analysis included framework analysis which was composed of five steps; data familiarisation, identifying a thematic framework, indexing, coding, classification, charting and mapping, as well as interpretation (Cloete, 2007, Johnson & Schoeneboom, 2017). In the context of the Bekkersdal study, data familiarisation focused on reading and transcribing of the data as well as interpretation and mapping data on why households in the area are vulnerable. Also, information from field notes were used to inform and supplement qualitative information. That is, other things that could not be captured in the questionnaire were catered for by the inclusion of field notes so as to cater for, among other things; social, economic and environmental ills experienced by the community of Bekkersdal. It is in this context that that researcher or field worker would experience first-hand, household challenges, behaviours and activities at the research site through taking some field notes (Creswell, 2014, Goundar, 2012).

The same process was followed with the questionnaire for disaster practitioners; that is, it had unstructured and open ended questionnaires, such as the examples below;

### **Disaster Preparedness and Prevention (Mitigation) Measures**

Please indicate types of measures used by the **West Rand District Municipality** (Bekkersdal, in the Westonia Local Municipality) to mitigate (preparedness and prevention measures to) the disaster risks/impacts.

## **What are the challenges and risks experienced by the West Rand District Municipality (Bekkersdal in the Westonaria Local Municipality) in Managing Disaster Risks?**

Unstructured questions have one primary advantage: they allow the respondent to share insights on the issue at hand and express their views freely and openly (Sesay, 2012:77-78). Some of the drawbacks of open-ended questions are that they require too much time for reasoning, which often negatively affects the response rate and data quality. For the researcher, open-ended questions require more time to analyse. For this particular study, open ended questions were therefore kept very few. In addition, to gain more qualitative information, field researchers were required to observe the behaviour and environment of the respondent. That is, the socioeconomic and environmental conditions of the households and any other information that households experience or are vulnerable to. In this regard, field workers prepared field notes which were then used to corroborate and enrich information from the predetermined questionnaire. Thus, the blending together of close- and open-ended questions and observations, were key in the study so as to ensure that credible information was captured. Close and open-ended questions reinforced each other to give a complete picture of the extent and magnitude of vulnerability in Bekkersdal. On the qualitative aspects, data from unstructured and open-ended questions were grouped, then edited for quality control processes (such as response inconsistencies and vague answers) and finally organised into thematic areas for analysis purposes, as it had significance for the purpose of the study. This was in line with Schutte (2006) and Cropley (2019) arguments that when organising and classifying data, the researcher should use themes. As such the responses were arranged into different themes and frameworks. Thus, information from the unstructured part of the questionnaire formed the basis for the qualitative part of the analysis.

## **5.4 CHALLENGES EXPERIENCED IN RESEARCH AND DATA COLLECTION**

Just like any survey, the data collection process encountered a number of challenges, including cases where respondents resisted answering some questions, or wanted to answer some in return for benefiting directly from the survey. However, it was explained to the respondents that the survey would be for the benefit of the community and government, in terms of ensuring effective targeting of households that are the most vulnerable to the disaster risks, instead of the one-size-fit-all approach currently practised.

Further, there were challenges with access to survey areas as there were service delivery protests in 2013/14 prior to the survey period of the study, during the survey period in 2015, as well as in 2016, resulting in the area being volatile as highlighted in Chapter 4 – refer to the following sources: Whittles (2015), Lindeque (2015), Rahlaga (2015), news24.com (2015), Lekaba (2014), Poplak (2014), Sosibo (2013) respectively. These articles highlight the violent protests, which were characterised by the looting of shops, arrests of people, and destruction of public property in Bekkersdal as people protested the lack of/limited access basic services, as well expressed their unhappiness with the RWC municipality, demanding that it be placed under administration. Further reporting of the strike action was by Magubane (2015) and South African Government News (2015), while the breaking out of violent protests in response to lack of basic services in Bekkersdal informal settlements has also been investigated by Khaba and Van Eeden (2016) and Van Eeden and Diedericks (2016).

The coincidence of the protests and the survey seems also to have been a factor in some households' reluctance to participate in the survey. However, when protests subsided, field workers had to engage respondents. Further, respondents raised concerns on whether their health-related information would remain confidential and whether it was solely for the purpose of the research. In this instance, respondents were assured that this information would be kept confidential with no names of the people being divulged whatsoever and would be solely for the study by the university only. There were also few instances where the respondents did not complete the questions in the questionnaire due to, among others; respondents indicating the questionnaire was long, or they had other commitments, or due to a history of non-response by the local

government officials on complaints or concerns they have raised in the past. There were also observations captured by the fieldworkers in the form of complaints by residents and challenges they encounter in the area through field notes. These findings are elaborated in Chapter 6 of the study.

## **5.5 LIMITATIONS AND DELIMITATIONS OF THE STUDY**

The study conducted in Bekkersdal community compared vulnerability levels to disaster risks in the area and coping mechanisms currently in place and used. This implies a case study approach since a sample was used for analysis. However, the potential for sampling error and biases cannot be ruled out. Generalisation arising from the study was limited, as the sample was a representative not the total population. On the other hand, resource constraints did not allow for a larger, more representative sample, though the sample size will generally be viewed as being sufficiently representative. On the delimitations of the study, it is important to note that the study was limited to Bekkersdal formal and informal areas. The study covered vulnerability to mainly disasters risks involving floods, fires, several mining-related activities and drought. The focal point of the study was not the individual, but the household (in the formal and the informal) in the Bekkersdal area.

## **5.6 ETHICAL CONSIDERATIONS**

The research was conducted according to the strict research guidelines of the North-West University. Ethical clearance and permission were granted to the Community Engagement Integrative Multidisciplinary Project related to the Environmental Health and Wellbeing of Mining Communities as an NRF-funded project to conduct research in Bekkersdal (see Ethics no. FH-BE-2013-0014). At the time (2013-2017), the Westonaria Local Municipality and the FWRD approved the IMD research in the Bekkersdal area (see Appendix 5, declaration form on research ethics). The case of Bekkersdal was complimentary to the 2013 baseline study that the Project Team conducted in the area, though with a much wider community scope and enriched focus on disaster risks. All the respondents signed a consent agreement (see Appendix 4, consent form). The consent form indicated that each respondent was not forced to participate in the survey and had to make that choice freely. In addition, their confidentiality was further assured as it was

indicated to them that the data collected was for the purposes of the present research and any information generated would be held with the strictest confidence.

## **5.7 CONCLUSION**

The chapter discussed the research methodology used in the study of households (formal and informal) to disaster risks in the Bekkersdal mining area of the RWC local municipality. In order to determine the variables leading to vulnerability levels of the selected households in the Bekkersdal mining community, a case study of Bekkersdal was adopted using a mixed method (quantitative and qualitative) approach, with a questionnaire-based survey used as a method of collecting the data. Once the process of administering the questionnaire was completed, the data cleaning and coding took place. In this case, just like in any other survey, there were missing values wherein such questionnaires were retained only if the missing data did not affect the representativeness of the findings. The coded information was organised, transcribed, and stored in Excel for descriptive analysis and STATA for econometric modelling as well as testing for credibility validity of the data.

The first part of data collection was descriptive, which basically described the sample or data collected. The aim of the descriptive part was to quantify the disaster risk vulnerability levels of the formal and informal households in the brittle mining area of Bekkersdal. This was so as to determine variables that have a bearing on household vulnerability. The second part to quantitative analysis reflected on the construction/estimation of the vulnerability index, which captured the vulnerability of formal and informal households of Bekkersdal. The study adopted the FANRPAN Household Vulnerability Index (HVI) as the main framework for identifying and comparing household vulnerability using 5 capitals: human, financial, physical, social and natural, as key drivers of vulnerability. The third part of quantitative data analysis involved estimating the key determinants of vulnerability. This was done using a simple Ordinary Least Square regression analysis method: to compare the drivers of vulnerability of households in the informal and formal areas of Bekkersdal.

The second part of the mixed method approach was the use of qualitative methods to collect data, so as to gain insight for a situational analysis of the community with respect

to disaster risks, and formulating themes/ frameworks. This was conducted through interviews. Discussions and field notes were also used to amplify this section, which enabled the capturing of some of the information that could not have been captured by the questionnaire. The data was classified, coded, edited for quality control processes and analysed. This is where themes and frameworks started to emerge, and the data was organised into thematic areas for ease of analysis. Thus, the blending together of close and open-ended questions, structured and unstructured questionnaires, as well as observations/ and field notes, were key for ensuring that credible and reliable data was captured. Whilst the process of data collection was taking place, challenges and limitations of the study were noted as highlighted above, including taking into account the ethical considerations in line with the University policy as indicated. Chapter six applies methodological approaches outlined above to the collected data and then presents the findings of the study.



## CHAPTER 6

### DATA ANALYSIS AND FINDINGS OF THE STUDY

#### INTRODUCTION

Determining the levels of vulnerability of households to various disaster risks is important for understanding the impact of disaster related risks in communities. Equally so, is understanding the determinants of vulnerability especially for informing policymakers on which social groups need to be targeted when a disaster strikes. In fact, literature highlights that by interrogating and finding out the determinants of vulnerability we derive insights on who is vulnerable, the causes thereof and what relevant course of action should be taken to reduce and address disaster related impacts (Ncube *et al.*, 2016, Islam *et al.*, 2012, Linnekamp *et al.*, 2011, Rana & Routray, 2018, FANRPAN, 2011, Shah *et al.*, 2017). More so for a community surrounded by mining activities, which is the case in the Bekkersdal area. The literature (see chapters 1,2,3 of this thesis) is clear that mining activities do have negative environmental effects in the form of acid mine drainage, dust, pollution, and formation of sinkholes, among others. To answer the question that the study seeks to address this chapter presents empirical evidence on the extent and determinants of vulnerability to disaster risks of households in the mining area of Bekkersdal. In this chapter the discussion does not differentiate formal and informal sector vulnerability as this comparison will be done in the Chapter 7.

For this chapter a holistic view of the sample has been prepared. The chapter is based on data collected through a survey questionnaire and interviews as was described in Chapter 5 of the thesis. The analysis contained in this chapter begins with some descriptive information from both the qualitative and quantitative aspects of the questionnaire, followed by vulnerability analysis. The main issues of interest in this subsection are graphical descriptions of the variables that have a bearing on household vulnerability, and indicators such as household asset ownership, household access to basic services, and household participation to social networks. In addition, basic information on economic and environmental risks, disaster events analysis, as well as

the mitigation and adaptation measures that households adopt or have access to when faced with the disaster event are interrogated.

The second section presents the results of analysis of responses to survey questionnaire by the district officers (WRDM) on their knowledge of disaster related risks in the Bekkersdal area, and how they have addressed or managed them. Thirdly, household vulnerability using a vulnerability index was analysed and discussed. The vulnerability index is based on a set of five capitals; namely, physical, human, financial, economic and environmental. The last part of the chapter isolates the determinants of vulnerability using regression analysis.

## **6.2 DESCRIPTIVE ANALYSIS OF THE BEKKERSDAL HOUSEHOLDS**

### **6.2.1 Household Demographics**

The sample of Bekkersdal comprised of 1 000 households and of those interviewed, females accounted for 66% while the remainder were males. The average age of the household head was 42 years. Both men and women shared this average (42 years). Figure 31 represents the gender demographics of the households interviewed in the Bekkersdal community. Considering that the majority of households living in Bekkersdal are females, literature abounds with case studies and empirical evidence suggesting that females are the most vulnerable group to disaster related risks (refer to Chapters 2 and 3 of the study respectively).

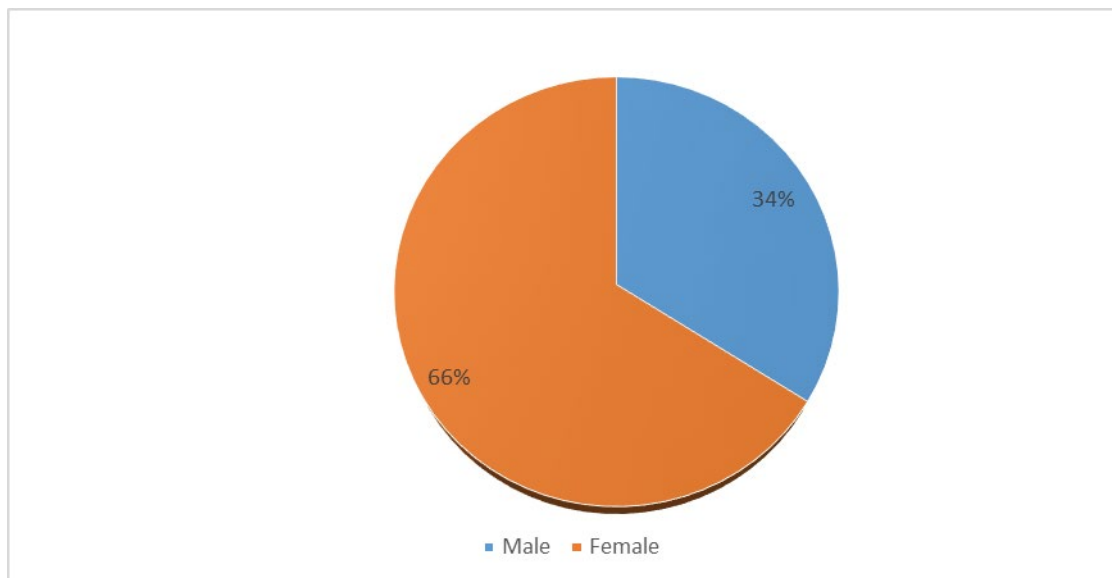


**Figure 31 Bekkersdal Household Gender Demographics**

Source: Primary Survey Data

### 6.2.2 Household Marital Status

Figure 32 shows the distribution of the sample of household heads in terms of marital status. The results show that 59% of the household heads are single, 23% are married, and 11%, 2.5%, 2.9% and 2.2% are widowed, divorced, separated or cohabiting, respectively. Literature indicates that household heads that are single, divorced or widowed are the most vulnerable to disaster impacts and would therefore need extra support to cushion themselves from disaster effects (Takashi, 2010, Usamah, 2014, Abunyewah *et al.*, 2018). In the case of Bekkersdal the majority of households' heads are single, and as such are vulnerable to disaster risks in the area and would require extra resources when a disaster event strikes.

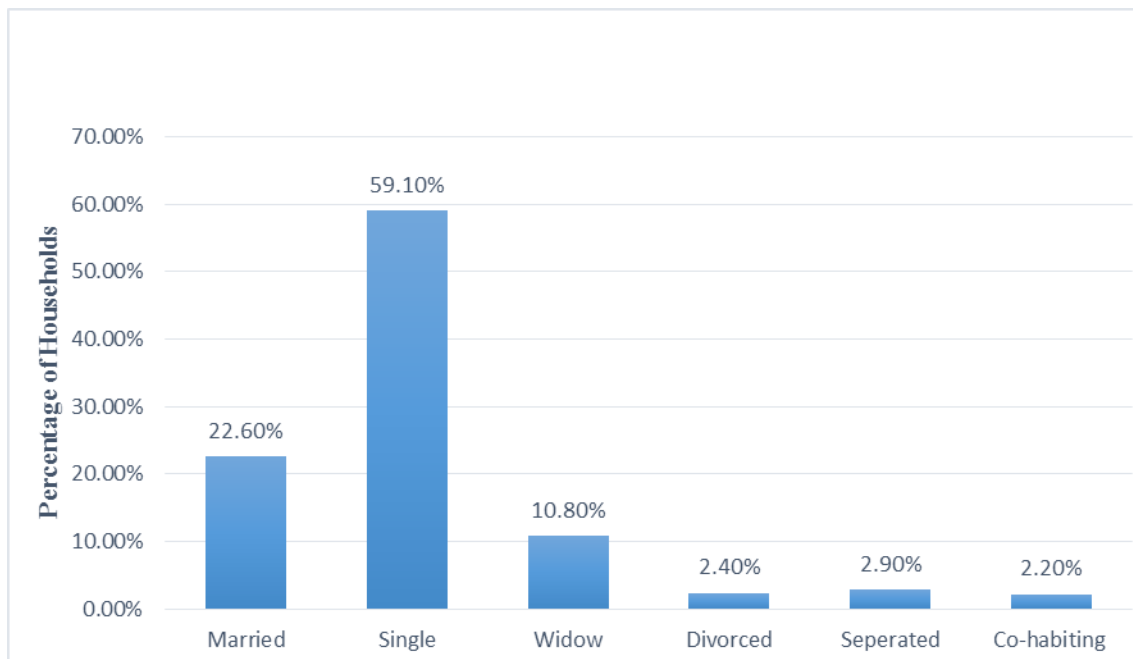


**Figure 32 Bekkersdal Households Marital Status**

Source: Primary Survey Data

### 6.2.3 Main Languages in Bekkersdal

The literature emphasised the need for officials to use languages familiar to or spoken by the community when disaster strikes or in times of recovery so that households understand the information articulated by the disaster risk officials. In Bekkersdal, the dominant languages are Xhosa (42%), Sesotho (18.6%), Tswana (12.6%) and Zulu (12.4%) respectively, as shown in Table 9.

These languages spoken in the Bekkersdal area are in line with the Statistics South Africa census (2011). The 2011 census outcome highlights that Xhosa, Sesotho, Tswana and Zulu are the main languages spoken in the area. Other than the official languages of South Africa, there are also other languages spoken in Bekkersdal, including Shona, siSwati and Chichewa, which indicates Southern African populations within the community. Overall, the multiple languages spoken in the area indicate the diverse history of South African mining areas and suggest the prominence of migrant workers from the neighbouring countries as has been discussed in Chapter 4 of the study. The diversity in languages spoken in Bekkersdal, imply that disaster risk officers

responsible for management of disaster risks in the area should have diverse communication strategies when dealing with or addressing risks in the area.

**Table 9 Languages Spoken by the Bekkersdal Community**

|           |       |
|-----------|-------|
| Xhosa     | 42.4% |
| Sesotho   | 18.6% |
| Tswana    | 12.6% |
| Zulu      | 12.4% |
| Xitsonga  | 9.0%  |
| Shangaan  | 1.2%  |
| Shona     | 0.9%  |
| Swati     | 0.8%  |
| Sepedi    | 0.5%  |
| Venda     | 0.4%  |
| Afrikaans | 0.4%  |
| Chichewa  | 0.3%  |
| Other     | 0.4%  |

Source: Primary Survey Data

#### **6.2.4 Residential Status of Households**

From the survey administered, households were also asked about their residential status to establish their citizenship. The results in Figure 33 below indicated that the majority of Bekkersdal households are South African citizens at 81%, followed by immigrants at 13% while the rest of the residents were either visitors or only there just for work purposes at 2% and 3%, respectively. A reason for the diversity of households residing in Bekkersdal could be the employment opportunities offered by mining companies in the area, resulting on inward migration from provinces such as Eastern Cape, KwaZulu Natal and Limpopo as well as from neighbouring countries such as Zimbabwe, Mozambique and Lesotho.

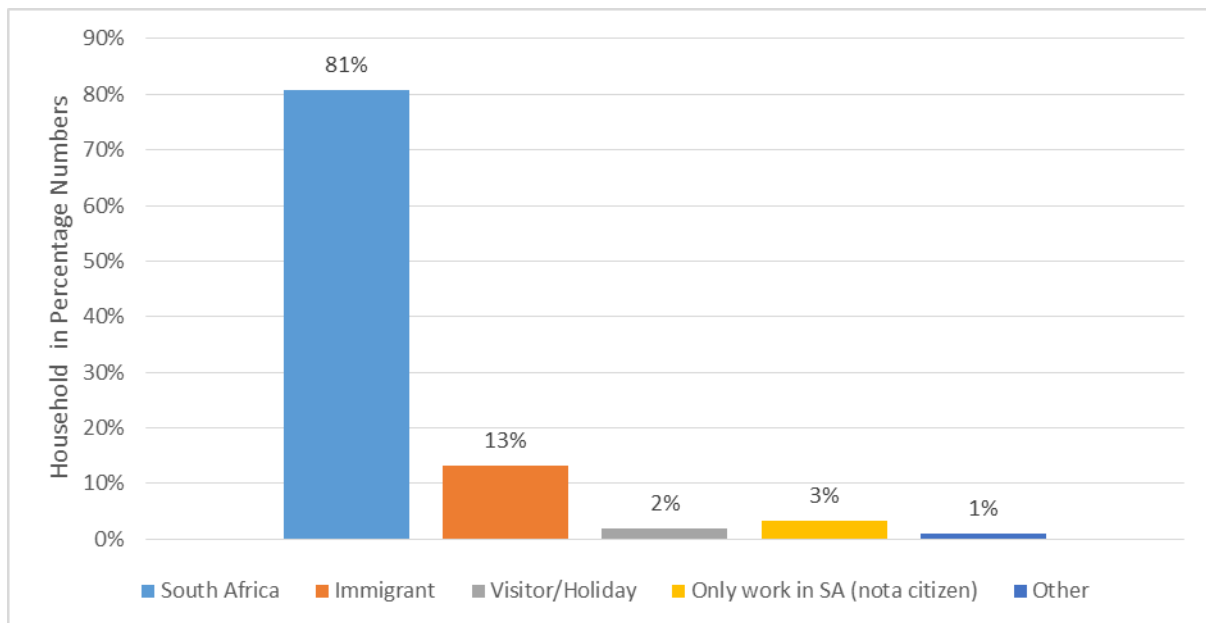


**Figure 33 Household Residential Status**

Source: Primary Survey Data

### 6.2.5 Household Educational Status

The literature is quite clear that to appreciate society's vulnerability, one needs to understand the socioeconomic and environmental circumstances or dynamic pressures and the demographic factors that households find themselves under. There are several socioeconomic and environmental variables that have a bearing on a community's or household's vulnerability. Education is one key variable that can explain vulnerability (Adebimpe, 2011, Parker, 1994, Barry *et al.*, 2011, Nnadi *et al.*, 2019). Literature abounds with evidence indicating that vulnerability is negatively related to education. Individuals with higher levels of education are less vulnerable compared to households with less education. Figure 34 shows a profile of the education levels of the sample. The majority of households in the Bekkersdal area have some high school qualification (49%), followed by those who have at least had primary school education at (30%). Illiterate individuals account for (7%), with university or college graduates accounting for only (2%), respectively. What was noted in the results, are the low levels of education at post matric levels. The results are also in line with the 2011 census results which showed low levels of education at post matric level in Bekkersdal. As a result, Bekkersdal households are increasingly vulnerable to disaster risks, and due to the low

levels of education attained they do not have resources at their disposal to cushion themselves from disaster related impacts.

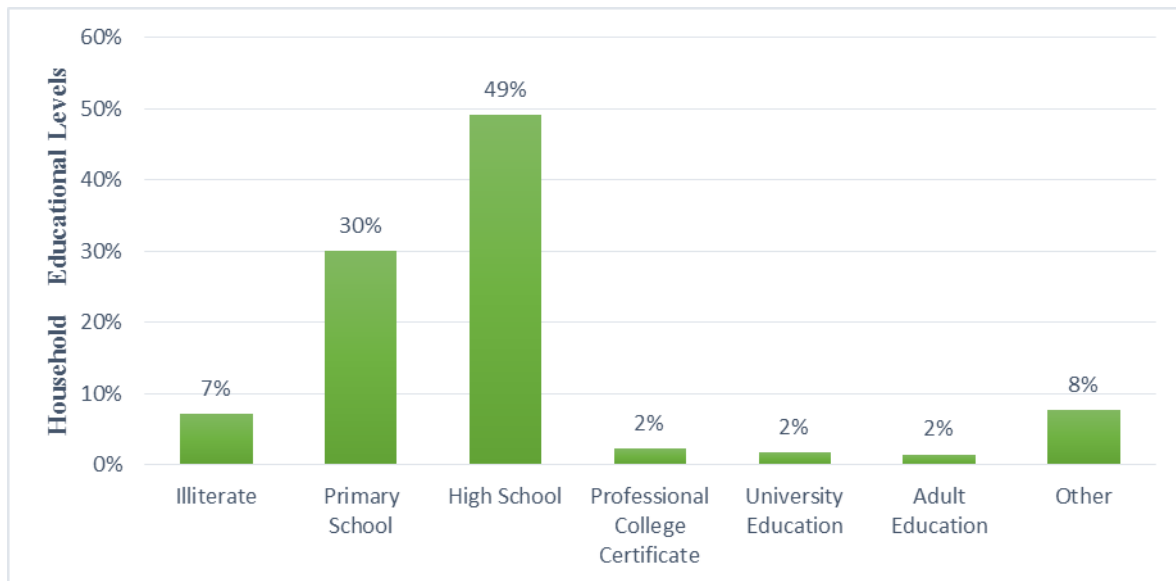


**Figure 34 Household Educational Status**

Source: Primary Survey Data

### 6.2.6 Household Employment Status

Employment status is another important variable when assessing vulnerability. Literature is quite clear as discussed in Chapters 2 and 3 of the study that employed people are less vulnerable as income earned from employment can cushion households from vulnerability. The results show that a whopping majority of households in Bekkersdal are unemployed 64%, followed by the employed at 36%, as indicated in Figure 35. The results indicate a dire situation characterised by high vulnerability for the households of Bekkersdal due to, among others, the high levels of unemployment which are a norm in South Africa's townships and in mining communities. The situation is further exacerbated by closure of mines over the years due to declining mining production (Van Eeden & Diedericks, 2016, Koen *et al.*, 2017). Literature further indicates that households who are unemployed become vulnerable when disaster risks strike due to non-existence or limited resources to cushion themselves (Kurosaki *et al.*, 2011, Williams *et al.*, 2018).

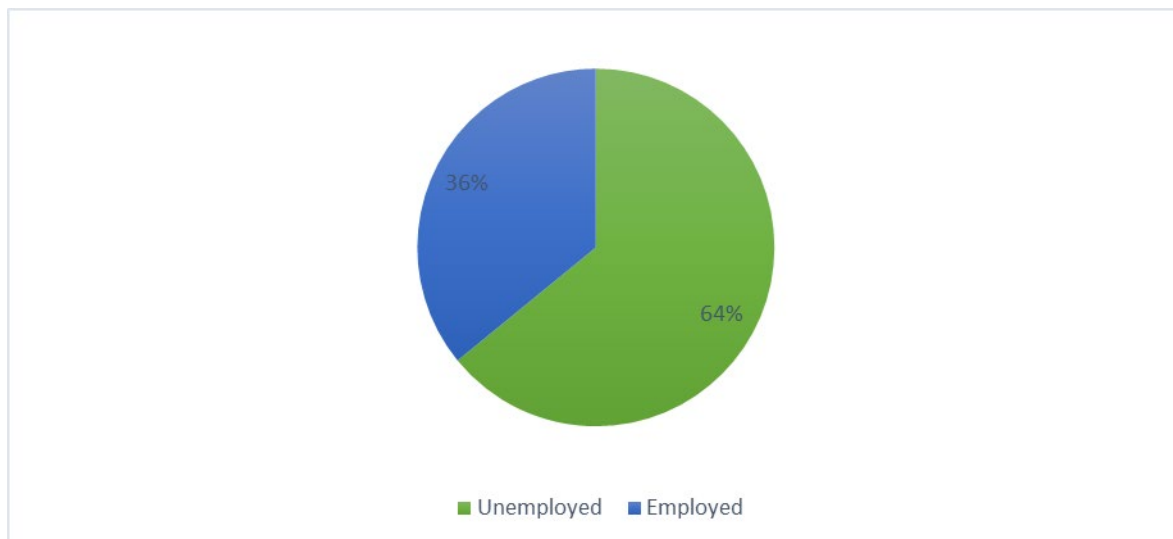


**Figure 35 Household Employment Status**

Source: Primary Survey Data

### 6.2.7 Type of Housing Structure

In terms of housing structures, households were asked to identify the type of housing structure they reside in (brick, RDP, wood, mud, shack or other). Again, on the basis of these indicators, one expects those living in mud houses or shacks to be more vulnerable than those living in other types of housing structures. Further, the literature as discussed in the study is clear that the type of housing structure that a household lives in, plays a crucial role in establishing household vulnerability levels. Those who living in brick houses are less susceptible to disaster related risks than their counterparts in shacks or mud houses. In the Bekkersdal area, the results indicate that the majority of the households dwell in shacks at 72%, with few households that reside in brick houses at 24% and 1.5% in the RDP houses, respectively. The rest of the households were spread between mud and wood structures at 0.4%, each (see Table 10). Though the results of the Bekkersdal household survey are not surprising as preceding chapters highlighted the negative social impacts that township households generally face, households tend to reside in highly densely populated informal settlement areas that are prone to floods (flood plain areas) and fires (shacks and densely populated areas). Residents living in unsafe structures as well as the informal settlement areas (unsafe with dolomites and sinkholes) were people who were working



in mines and wanted to be closer to areas of work, and in some instances, those that had been retrenched (Costella & Oyadiya, 2014, Williams *et al.*, 2018, Koen *et al.*, 2014).

**Table 10 Bekkersdal Housing Structure**

| Type of Housing Structures | Percentage of Households in Housing Structures |
|----------------------------|------------------------------------------------|
| Brick                      | 24.4%                                          |
| RDP                        | 1.5%                                           |
| Wood                       | 0.4%                                           |
| Mud                        | 0.4%                                           |
| Shack                      | 72.1%                                          |
| Other                      | 1.2%                                           |

Source: Primary Survey Data

### **6.2.8 Household Health Status**

Literature reviewed in the preceding chapters indicates that vulnerability is also a function of one's health status. People afflicted by disease and illness are more vulnerable than healthy individuals. Often, their incomes are used to defray health related costs, instead of building resilience to disaster events. Literature in Chapters 2 and 3 of the study emphasised that households who are ill are generally more vulnerable in comparison to those that are healthy or well, and even more so when they are hit hard by any disaster related event. In terms of health status, Bekkersdal households were reported to be generally healthy at 61% as shown in Figure 36 below.

The rest of the population reported exposure to chronic diseases such as high blood pressure related diseases (15%), with 12% reporting HIV positive status and 4% of the sample interviewed reporting diabetes. The rest of the illnesses households were exposed to are tuberculosis, pneumonia, body pains, stomach aches, arthritis, asthma, cancer and others such as skin rash and cholera. The results are interesting given the history of Bekkersdal as alluded to in Chapter 4 of this study as well as in the literature review. For instance, the survey results corroborate the literature reviewed and historical profile of Bekkersdal as presented in the preceding chapters. The preceding

chapters highlighted that households residing in mining areas and working in mines become exposed to respiratory illness in the form of tuberculosis/pneumonia and bronchitis, and cancer due to contamination of soil, water and the air by mining metals. High levels of HIV/AIDS have been associated with migratory labour effects, prostitution and substance abuse. Other illnesses such as diarrhoea, cholera and skin rash, were also highlighted as major challenges exacerbating the vulnerability levels of Bekkersdal households. These are discussed further in upcoming sections.

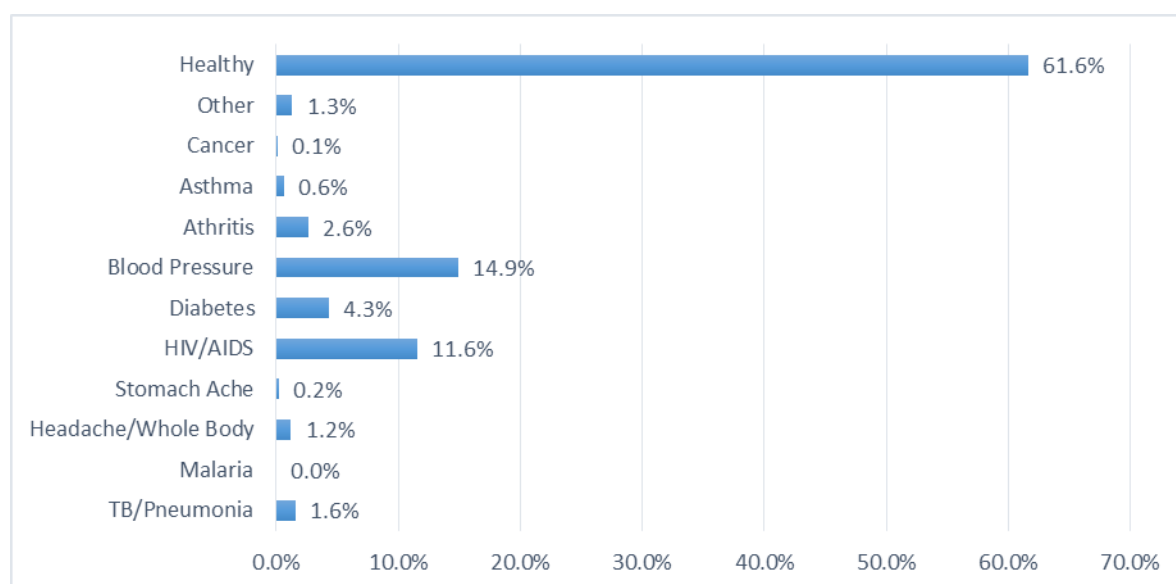


**Figure 36 Household Health Status**

Source: Primary Survey Data

### 6.3 HOUSEHOLD LIVELIHOOD ASSET STATUS

In order to understand the vulnerability of households to disaster risks, various measures, both external and internal were used. The most common framework that captures both external and internal dimensions of vulnerability is the Sustainable Livelihoods Framework (SLF) introduced by the Department for International Development of the United Kingdom (DFID, 2000) as discussed in Chapters 2 and 3 respectively. The SLF analyses the livelihoods of the poor, through the lens of 5 capitals; financial, human, natural, physical and social. A household that has limited access to (i) natural assets (such as land, good soil and water); (ii) physical assets (such as livestock and equipment); (iii) financial assets like (savings, salaries, remittances or pensions); (iv) human capital assets (for example knowledge, skills,

ability to work, good health); and (v) social assets (like information, community support, extended families and formal or informal social welfare support) will be vulnerable to disasters.

### **6.3.1 Household Assets/ Capital**

This section provides a descriptive overview of households' access to the five assets or capitals. Households in the Bekkersdal were asked whether they own land, farm, mine, livestock, house/property, business or any other assets. Households with poor livelihood assets are more vulnerable than their counterparts with assets. Asset ownership enables households to secure their livelihoods when they are faced with adverse conditions. Literature also contends that households with assets are able to reduce disaster impacts as assets enable them to smoothen their consumption of goods and services (Vatsa, 2004 Twigg *et al.*, 2001, Smith & Frankenberger, 2018). Household asset ownership profiles shown in Figure 37 below suggests that the majority of households do not own any land, farm, mine, livestock, property or business (89%, 96%, 99%, 88%, 59% and 85 % respectively). Interestingly, even when it comes to 'other assets' not listed above, that households may have, the response was 83% have no 'other assets', an indication that households in the Bekkersdal have limited assets, comprising either financial assets (savings, salaries to cushion themselves where disaster risks occur) or social assets (in terms of welfare support), let alone human assets (skills or knowledge) or physical assets (livestock, for example) which are assets they can use to reduce the impact of disaster events. If households are lacking in any form of assets it is an indication that they are less resilient to some disaster risks. The concept of sustainable livelihoods asserts that when households possess any of the five capitals, they become more resilient in the face of disasters than households that do not (Yang, Feldman & Li, 2020). When a disaster strikes households with assets draw down on their capitals. According to Vincent and Cull (2010) possession of the five capitals/assets reduces household vulnerability.

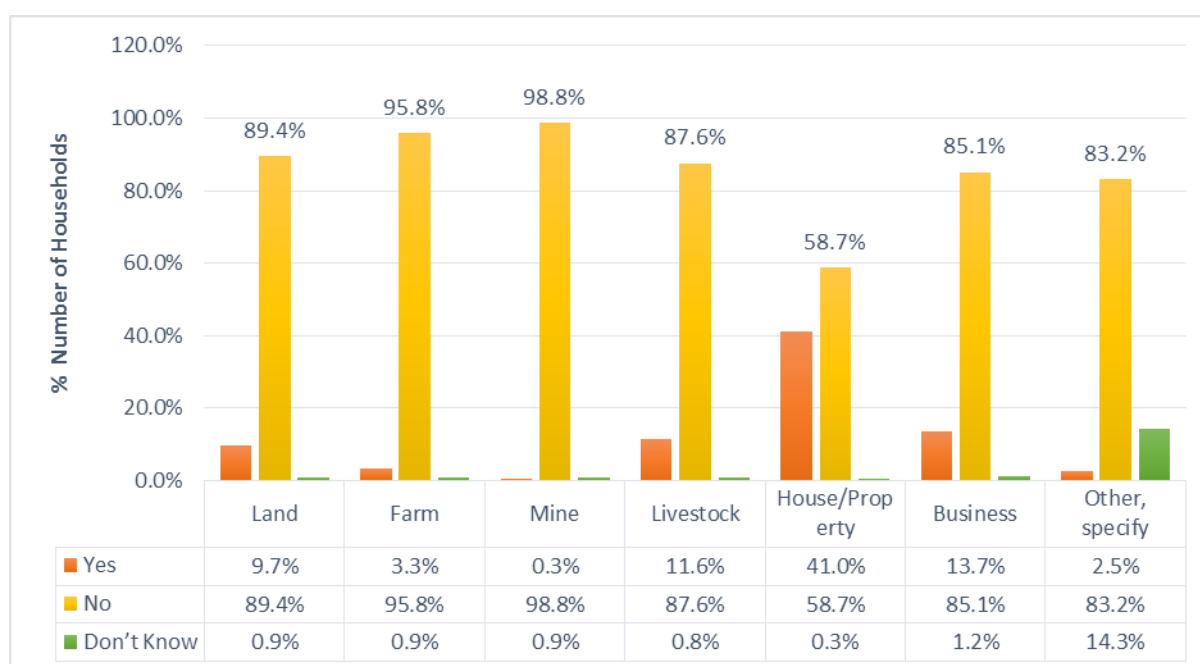


**Figure 37 Household Livelihood Assets**

Source: Primary Survey Data

### 6.3.2 Household Access to Basic Services

Households of Bekkersdal, were further probed on whether they have access to basic services (electricity, water and sanitation, sewerage system), roads/transport, telephones and financial services. As discussed in Chapters 2 and 3 these basic services are critical for households to withstand the impacts of disaster related risks. Figure 38 provides some insights into the proportions of households that have access to basic services and other vital amenities. Households with access to electricity and sanitation were at 30% and 44%, respectively. The above results concur with the Stats SA (2011) figures whereby relatively a low percentage of households in Bekkersdal had access to electricity and sewerage at 39.6% and 37%, respectively. Further, only 58%, 57% and 58% of the sampled households have access to running water, sewerage and goods produced locally. The lack of access to these basic services in the Bekkersdal area corroborates the literature reviewed on lack of basic services in the area, which in turn has been the cause of service delivery protests. It can also be argued that the decades of mining activities in Bekkersdal have negatively affected the development of basic services. For instance, gold mining activities affect quantity and quality of water

services, and in Bekkersdal, the quality of water is poor due to mine effluents and metals found in ground and water surface. Further, water supply is inadequate as mining activities consume high volumes of water.

Limited access to these basic services implied, among other things, the use of illegal electricity connections by households (that further aggregates risks) and the use of ground water which is not purified, resulting in households using mine effluent polluted water for livelihoods (such as drinking and agricultural activities). Mining in the area and the closure of mines has caused environmental degradation in the form of open pits, and quarries which have been used by households as waste dumps/illegal dumping sites due to non-collection of refuse removals. Access to roads and transportation is reasonably high at 69%, while access to financial services was at 76%, and access to locally produced goods at 58%. With the boom in mobile phones/smart phones in South Africa, it is hardly surprising that 84% of households indicated access to telephones. Telephones are important assets in ameliorating the impact of disasters as households can communicate with those involved and responsible for disaster risks in the area.

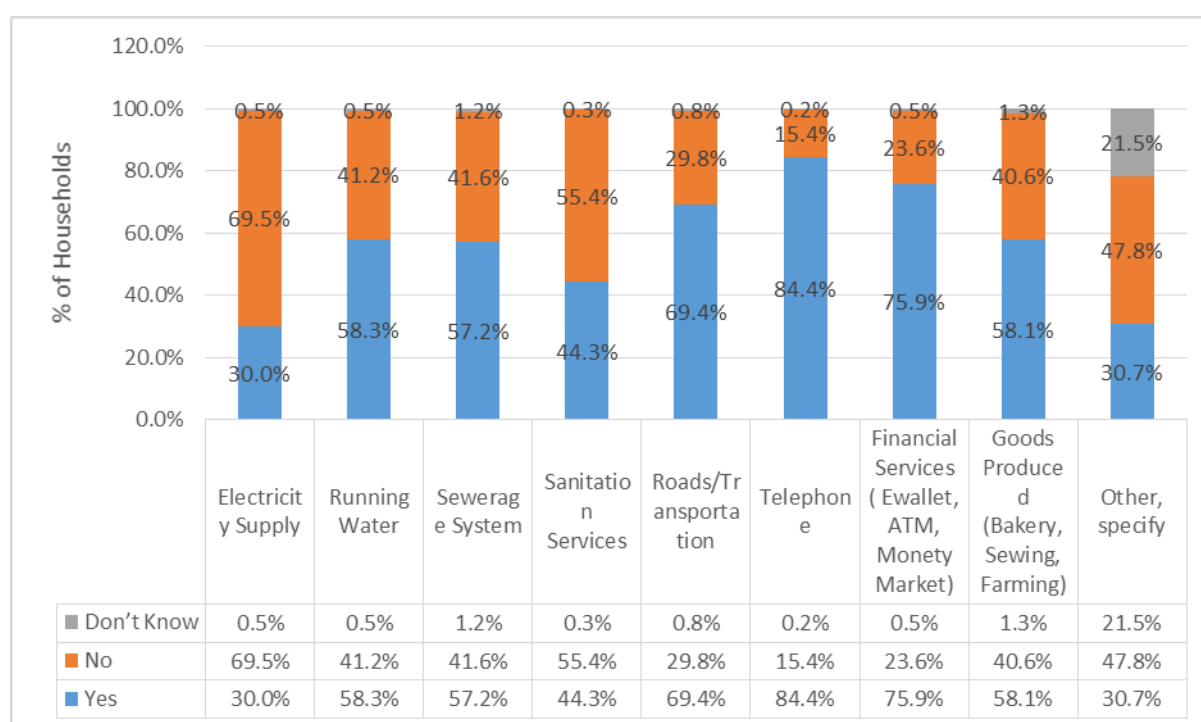


**Figure 18 Access to Basic Services**

Source: Primary Survey Data

### 6.3.3 Household Social Protection

Literature also states that social protection mechanisms minimise individual, household and community vulnerability (Vatsa, 2004, Costella & Oyadiya, 2014, Ibrahim *et al.*, 2018, Matyas & Pelling, 2012, Aleksandrova, 2019). Social protection variables include social networks, social grants, food security programmes, income allowances, insurance coverage for goods, and skills or apprenticeships programmes. Literature is clear that individuals may withstand a disaster significantly if they have social networks, have access to social grants or food security programmes, or have the skills to ensure productive employment. The point here is that livelihood diversification, where communities have diverse social support capabilities is critical for withstanding disaster risks. The argument is that, social networks are built on the premise of shared norms and standards that in turn enable cooperation and coordination within and among groups in the society (Department of Human Settlement, 2016). The study examined the extent to which households in Bekkersdal have access to some of these social protection services, and the results were mixed.

The results in Figure 39 indicate that about 83% of the households have no insurance cover for their household goods; an indication that when a disaster strikes, and the majority of household goods or homes are destroyed they cannot be recovered. Only 56% of households in Bekkersdal have income allowances, while about 55% of households do not have access to social grants. In addition, 49% of households do not participate in social networks such as social clubs or *stokvels* (community savings society); another indication that many households are likely to be vulnerable, as there is limited social cohesion among the community. At most, about 64% of households do not participate in food security programmes such as food gardening or communal services, clearly showing food insecurity in the area, which in turn results in hunger. Also, skills acquisition has been less prevalent as only about a quarter of households were in a skill acquisition programme of one form or another, with the majority without any skill acquisitions that may be used for their benefit or in terms of making ends meet for their families.

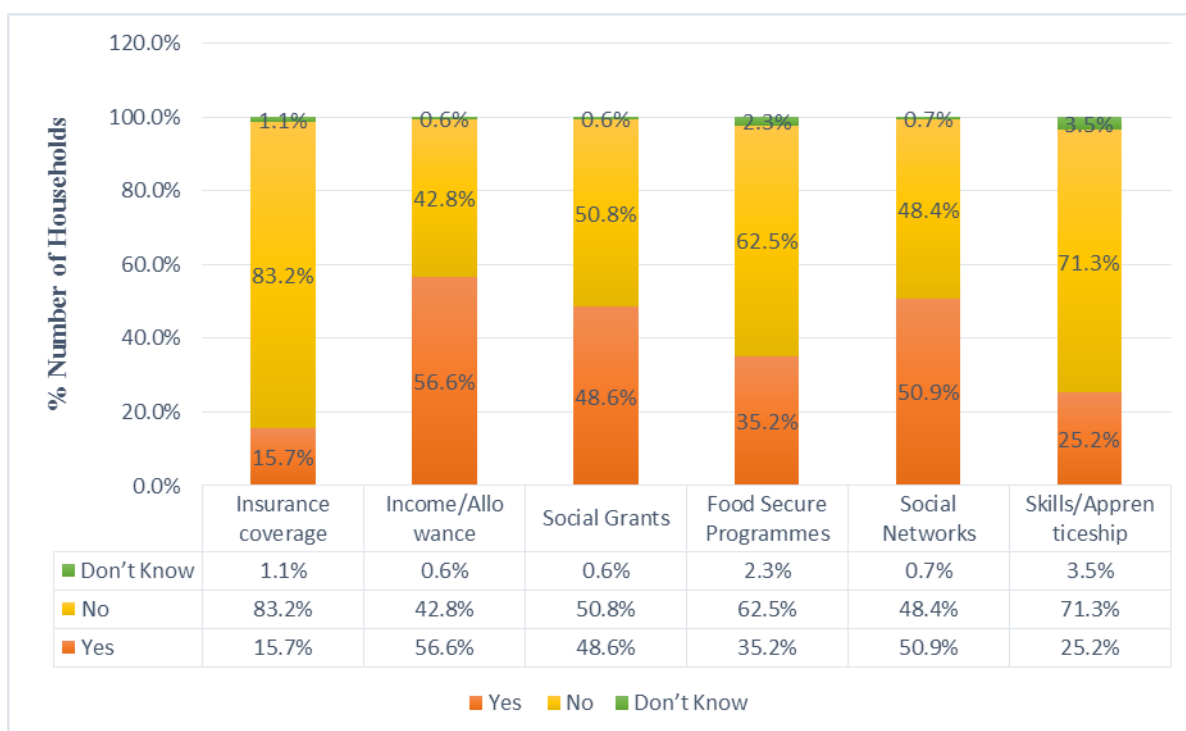


**Figure 39 Household Participation in Social Protection Networks**

Source: Primary Survey Data

## 6.4 DISASTER RELATED RISKS

### 6.4.1 Waterborne Related Diseases in Bekkersdal

Mining activities do have negative environmental impacts and as such have affected the community and households of Bekkersdal. To this effect, households were asked whether they have been affected by any of the waterborne diseases in the area like cholera, skin diseases, and bilharzia, among others. Household responses varied. Some households indicated that they have been affected by waterborne diseases such as skin rash, fever, diarrhoea and tuberculosis. Households described the causes of those waterborne diseases as ranging from dirty water and running sewerage in the streets, to children swimming in the dam, as well others fetching water in the Donaldson dam for household activities or farming use. The responses highlighted corroborate literature reviewed in the preceding chapters on the poor status of water supply in the Bekkersdal community. For instance, water supply to households of Bekkersdal has not

been purified, so both the surface and underground water give rise to waterborne diseases.

There is also Donaldson dam which has high levels of acid mine drainage, toxic and radioactive materials because of years of mining activities and mine waste in the area (also discussed in Chapters 1, 2,3 and 4 of this thesis). The polluted water in the Donaldson dam has been used for households' consumption and livelihood activities and as such is harmful to household health. Possible health issues arising from its consumption range from cancer, decreased cognitive function and neural development defects of the foetus which can lead to developmental disabilities, to health effects such as skin rashes, diarrhoea, respiratory illnesses, and children often getting sick due to dirty water as some swim in the dam (see Figure 40). Thus, the emerging theme from the results in table 11 indicate that Bekkersdal households are affected and infected by water related diseases

To the question: has the household been affected by any of water diseases like cholera, skin diseases and bilharzia (skin rash) or any other? Some of the direct responses received are as stated in Table 11:



**Table 11 Direct Responses by Households on Water Related Diseases**

|   |                                                                                                                                                                                                                          |
|---|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | <ul style="list-style-type: none"> <li>Respondent #117 'Bilharzia (skin rash), cholera, weakness/dizziness, fever and headache.'</li> </ul>                                                                              |
| 2 | <ul style="list-style-type: none"> <li>Respondent #154 'Yes, itching skin rash due to dirty water, sewerage and diarrhoea'.</li> </ul>                                                                                   |
| 3 | <ul style="list-style-type: none"> <li>Respondent #257 'The household has been affected by skin diseases in the last two months when the young one was playing the dam'.</li> </ul>                                      |
| 4 | <ul style="list-style-type: none"> <li>diseases in the last two months when the young one was playing the dam</li> </ul>                                                                                                 |
| 5 | <ul style="list-style-type: none"> <li>Respondent #612' The 6 year old was affected by skin rash last year but do get medication to care for the disease'.</li> </ul>                                                    |
| 6 | <ul style="list-style-type: none"> <li>Respondent # 535'The household has been affected by the water diseases because they stay closer to the sewerage system and drains are always overflowing in the area'.</li> </ul> |
| 7 | <ul style="list-style-type: none"> <li>Respondent #837 'Affected by water disease and other sickness including skin rash but we are on treatment'.</li> </ul>                                                            |
| 8 | <ul style="list-style-type: none"> <li>Respondent # 266Yes, infact bekkersdal is surrounded by surage and the cause of disease we get is coming from the surage or water pollution</li> </ul>                            |
| 9 | <ul style="list-style-type: none"> <li>Respondent #289 Yes, because the dirty enviroment of informal settlement. They / Children has sore all over the body or they have skin rash</li> </ul>                            |



**Figure 40 Children Swimming in Donaldson Dam, despite toxicity of water**

Source: (Beeld, 2014)

### 6.4.2 Intensity and Significance of Disaster Risks Experienced

Households in the Bekkersdal area were asked to rate disaster related risks that they have experienced in the area over the last three years. A Likert scale was adopted to assess whether such disasters were very significant, significant or not significant to the household. Interestingly, on all the disaster related events listed in Table 12, social unrest was reported as very significant by 53% of the household. This is not surprising given the violent nature of social and basic service delivery protests that have occurred in the area over the past three decades as discussed in Chapter 4 of this study. Mining related incidents (such as dust, earth tremors) were reported as very significant at 52% of households, corroborating what literature highlighted in the preceding chapters of this study, where mining activities have negative environmental effects which make households in the area vulnerable to disaster risks. Likewise, fires were reported as very significant (40%) which can be attributed to various factors as the literature has highlighted in preceding chapters, with shack fires common especially in the informal area of Bekkersdal. Disease outbreaks and sinkholes were reported to be very significant at 37% and 30%, respectively, in line with scholarly findings discussed in the preceding chapters. Disaster events such as earthquakes, droughts, flooding, windstorms and sinkholes were reported to be not so significant, occurring occasionally.

**Table 12 Disaster events in the Bekkersdal area**

| <b>Disaster Events in Bekkersdal</b>           | <b>Very<sup>12</sup><br/>Significant</b> | <b>Significant<sup>13</sup></b> | <b>Not<sup>14</sup><br/>Significant</b> |
|------------------------------------------------|------------------------------------------|---------------------------------|-----------------------------------------|
| Droughts                                       | 10%                                      | 32%                             | 58%                                     |
| Sinkholes                                      | 32%                                      | 27%                             | 41%                                     |
| Windstorms                                     | 14%                                      | 39%                             | 47%                                     |
| Earthquakes                                    | 9%                                       | 31%                             | 60%                                     |
| Mining related incidents (dust, earth tremors) | 52%                                      | 23%                             | 25%                                     |
| Flooding                                       | 18%                                      | 28%                             | 53%                                     |

---

<sup>12</sup> Very significant= impact daily;

<sup>13</sup> Significant = impact weekly;

<sup>14</sup> Not significant= impact monthly or seldom

|                                            |     |     |     |
|--------------------------------------------|-----|-----|-----|
| Fires                                      | 40% | 26% | 34% |
| Social Unrests (service delivery protests) | 53% | 19% | 28% |
| Health Outbreaks (cholera)                 | 37% | 22% | 41% |

Source: Primary Survey Data

#### 6.4.3 Significant Disaster Related Risks in Bekkersdal

On the risks identified in Table 12, households were further probed to indicate in their own words or perspective, the most problematic and significant disaster risk related events. 87% percent of households identified: crime, unemployment, dust, earth tremors, mining related incidents, shack fires (see Figure 41), social unrests, illegal connection of electricity, sewerage, heavy rains and floods, water and sewerage hazards/pollution, disease outbreaks (cholera, HIV/AIDS), service delivery protests, waste dumping sites (see Figure 42), and xenophobic attacks as the emerging theme in relation to significant disaster related risks in the Bekkersdal.

These disaster related risks and challenges mentioned by the households are in line with what the literature review highlighted, where disease outbreaks have been associated with waterborne diseases in the area, attributed to the legacy of mining activities that have negatively impacted the surface and underground water resulting in pollution and related illnesses such as cholera and respiratory disease in households. Pollution such as dust has been due to mining waste dumps, with open pits becoming sites of illegal dumping of waste, and when there are heavy rains they cause to flooding. Also, shack fires, substance abuse, illegal electricity connections and spread of HIV/AIDS can be attributed to various reasons. These include densely populated areas where unplanned informal settlements have been built with limited or no access to basic services, shack fires caused by, among others, the use of traditional methods of cooking and lighting such as paraffin or candle or illegal electricity connections. Some of the direct responses from households on what are the significant disaster related risks experienced by households in Bekkersdal are given in Table 13:

**Table 13 Direct Responses: Most Significant Disaster Risks**

|    |                                                                                                                                                                                      |
|----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1  | <ul style="list-style-type: none"> <li>• Respondent #2 'Electricity and sewerage system'</li> <li>• Respondent # 137 'Izinyoka-nyoka) illegal electricity',</li> </ul>               |
| 2  | <ul style="list-style-type: none"> <li>• Respondent # ' Shortage of water, flushing toilet system,</li> <li>• Respondent # 281 'RDP houses, unemployment, poverty'</li> </ul>        |
| 3  | <ul style="list-style-type: none"> <li>• Respondent #232 'Dumping site near our shack it will affect health'</li> </ul>                                                              |
| 4  | <ul style="list-style-type: none"> <li>• Respondent #237 ' Xenophobic attacks, health outbreak (cholera) malaria'</li> </ul>                                                         |
| 5  | <ul style="list-style-type: none"> <li>• Respondent # 608 'Water pollution, Water and toilet system are very poor'</li> </ul>                                                        |
| 6  | <ul style="list-style-type: none"> <li>• Respondent # 783 'Burning of shacks and people'</li> </ul>                                                                                  |
| 8  | <ul style="list-style-type: none"> <li>• Respondent #994 ' Fire and Flooding'</li> </ul>                                                                                             |
| 9  | <ul style="list-style-type: none"> <li>• Respondent #774 'Dust, fire, social unrest and water pollution'</li> </ul>                                                                  |
| 10 | <ul style="list-style-type: none"> <li>• Respondent #540 'Mining related incidents',</li> <li>• Respondent # 183# 'Women and child abuse, waste management'</li> </ul>               |
| 11 | <ul style="list-style-type: none"> <li>• Respondent # 5, 228, 573, 878 'Thugs, unemployment, crime, rape, drugs/ nyaope boys, drug dealers, gangsterism'</li> </ul>                  |
| 12 | <ul style="list-style-type: none"> <li>• Respondent # 632 'Sinkholes, Social unrest, Toy- toy (protest)'</li> <li>• Respondent #705 ' High population rate, overcrowding'</li> </ul> |



**Figure 41 Bekkersdal Community Members at the Shack: 3 Babies Killed During Fire**

Source: EWN (2018)





**Figure 42 Rubbish Litters the Landscape of Bekkersdal**

Mail and Guardian (2019)

#### **6.4.4 Management of Disaster Related Risks in Bekkersdal**

Households were further probed to come up with ideas as possible solutions on how the risks they have identified should be managed or resolved. About 90% of the households indicated management of disaster related risks as the establishment municipal disaster risk management unit which is dedicated to addressing disaster related risks; tarred roads to reduce dust and pollution; educational awareness campaigns and programmes and mitigation measures should form part of disaster risk mitigation strategies elimination of shacks; arresting those involved in illegal electricity connections and criminals; enforcing bylaws; planting of trees to minimise dust; improving infrastructure services such as roads; provision of basic services (water, electricity, toilets and sewerage systems); provision of emergency numbers so that households know who contact in the event of disasters; fire extinguishers; fire balls, building of fire guards as well as having municipal early warning facilities; and the use of traditional methods for extinguishing fires such as (sand/soil and water). Emerging from these results are the lack of management and mitigation measures to disaster related risks in the Bekkersdal and lack of knowledge by households of what they should be doing to minimise the

impacts related with these risks. 10% of households did not know how risks can be managed, nor have resources to do so. Emerging from these results are the lack of management and mitigation measures to disaster related risks in the Bekkersdal and lack of knowledge by households of what they should be doing to minimise the impacts related with these risks.

It is noteworthy though that households did not offer solutions on how the mining related risks (sinkholes, earth tremors, dust, and water pollution) can be managed or addressed. This may be interpreted as that household do not perceive mining related risks as a problem/challenge, and that they only view mining operations as a means to get jobs, as such, gold mining activities were hardly viewed by households as the biggest disaster risk factor in the area. Hence the negative mining related activities have seemingly somewhat been tolerated and appear remote. In terms of how the disaster risk challenges mentioned above, can be managed or addressed, direct responses from households are indicated in Table 14 below;

**Table 14 Direct Response by Households on Management of Disaster Risks**

| <b>Respondent # 87 'Proper management of the municipality and not having to subsidise people who don't want to pay for municipal services'</b> |                                                                                                                                                                                      |
|------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                | Respondent # 121 'Police must chase this theft and put in jail<br>Tar road to decrease dust and sinkholes'                                                                           |
|                                                                                                                                                | Respondent #221 'We can resolve this by given us illegal electricity and tap water<br>Send more police maybe the problem of crime will be solved'<br>Respondent # 314 'Job creation' |
|                                                                                                                                                | Respondent # 516 'Municipality must appoint people to come and educate us'                                                                                                           |
|                                                                                                                                                | Respondent # 615 'Our local municipality must remove that dumping side somewhere<br>Municipality must give them RDPs'                                                                |
|                                                                                                                                                | Respondent #700 'Municipal must put the flashing toilet or build a brick house'<br>Respondent # 750 'If our government could supply us with electricity there will                   |

|  |                                                                                                                                  |
|--|----------------------------------------------------------------------------------------------------------------------------------|
|  | be no fires'                                                                                                                     |
|  | Respondent 430 'Government must supply us by legal electricity in order for us to use it instead of candles and paraffin stoves' |
|  | # 221 'The community must join ventures with the municipality to resolve the matter'                                             |
|  | # 818 'The streets of Bekkersdal are full of sewerage and people get sick, if only the municipality can do something about that' |
|  | # 745 ' If people can be taught how to live a healthy life style'                                                                |
|  |                                                                                                                                  |
|  | # 616 'Job creation and skill program was the solution'                                                                          |
|  | # 743 'Many people in Bekkersdal has HIV/AIDS because of unemployment teenagers sell their body just because they need money'    |

## 6.5 ENVIRONMENTAL AND ECONOMIC RISK FACTORS

Households were further questioned on the risks (both economic and environmental) that they have encountered in the Bekkersdal area. Table 15 indicates that over 90% of households have been affected by crime and service delivery related risks, followed by dust and drug related risks at just over 80%, respectively. Informal settlements, inadequate sewerage treatment, waste disposal challenges and earth tremors were also considered major risks faced by households at about 70%. Also, land pollution was considered a risk by at least 60%, while high population density was seen as a risk factor by 56% of the households with just above 50% identifying wetlands destruction.

However, inappropriate land use was considered a risk by 46% of participants, while water pollution was considered a risk factor by 46%, dolomite by 41%, sink holes by 43%, and underground mining by 48%. These results are not surprising considering that the majority of the households in the area, reside in informal settlements which has its socioeconomic and environmental challenges as discussed in the preceding chapters in literature. As a result, issues critical in informal settlements are inadequate sewerage treatment, waste disposal challenges, service delivery, dust, crime and drugs.

It can be argued that some of these disaster risk related challenges can be attributed to the mining activities that have occurred in Bekkersdal over the years. For instance, the establishment of informal settlements due to shortage of houses following influx by people as a result of mining employment in the area and people residing near place of work. So too, the digging by mining companies resulted in open pits/quarries which in turn were used as waste dumps or for illegal dumping of waste by the households. The growth of informal settlements due to mining activity has stretched basic services delivery as such settlements were unplanned and inappropriate, resulting in service delivery protests in the area. The decline in gold mining production meant retrenchments of some of the mine workers, who once they did not have jobs and became unemployed turned to crime driving up crime rates. All this, as land pollution, wetlands destructions, inappropriate land use, dolomite, sinkholes, water pollution, underground mining and earth tremors were, too, negative impacts of mining activities stretching over decades in the area.

Therefore, it can be argued that service delivery has become a big risk or a secondary risk because of the mining and environmental activities that have and are taking place in the Bekkersdal mining community and surroundings. In other words, service delivery, is a secondary risk driven by other primary risks (such as the negative mining impacts) making it difficult and basically impossible to supply basic services in Bekkersdal due to unsuitable infrastructure and inappropriate land use as a result of mining activities.

Surprisingly, mining development, flooding, uncontrolled veld fires and acid mine water were considered to be risk factors only by 23%, 20%, 30% and 10% of the participants respectively, meaning that the majority do not perceive these as risk factors as per the table below. The little knowledge of mining related risks is arguably and worryingly very low in Bekkersdal. This is a mining town and people around the area are not aware of the risk associated with mining. Overall, it would seem the extensive impact of mining activities on past, present and potential disastrous circumstances of households is underplayed by communities, as these communities are occupied in the struggle to survive. They toil to survive and neglect the disastrous consequences of surrounding mines and the dangers that are not yet so visible to them that are posed by these negative mining activities.



**Table 15 Socioeconomic and Environmental Risks**

| <b>Socioeconomic and Environmental Risks</b> | <b>Yes</b> | <b>No</b> | <b>Don't Know</b> |
|----------------------------------------------|------------|-----------|-------------------|
| Mining and Industrial Development            | 23.3%      | 50.9%     | 25.7%             |
| Informal Settlements                         | 73.5%      | 16.1%     | 10.4%             |
| Uncontrolled Veld Fires                      | 30.6%      | 53.9%     | 15.5%             |
| Water Pollution                              | 46.4%      | 39.0%     | 14.6%             |
| Inadequate Sewage Treatment                  | 71.7%      | 21.0%     | 7.2%              |
| Waste Disposal Challenges                    | 73.4%      | 21.9%     | 4.7%              |
| Flooding                                     | 23.8%      | 62.0%     | 14.2%             |
| High Population Density                      | 56.6%      | 31.6%     | 11.9%             |
| Inappropriate Land Use                       | 45.9%      | 37.6%     | 16.4%             |
| Dolomite                                     | 41.2%      | 44.7%     | 14.1%             |
| Sinkholes                                    | 43.1%      | 47.5%     | 9.4%              |
| Acid Mine Water                              | 12.2%      | 63.0%     | 24.8%             |
| Wetlands Destruction                         | 50.5%      | 33.6%     | 16.0%             |
| Service Delivery                             | 91.1%      | 6.1%      | 2.7%              |
| Land Pollution                               | 66.9%      | 23.9%     | 9.2%              |
| Dust                                         | 84.4%      | 12.4%     | 3.2%              |
| Underground Mining                           | 48.3%      | 33.5%     | 18.2%             |
| Earth Tremors                                | 70.7%      | 14.8%     | 14.5%             |
| Crime                                        | 93.0%      | 5.6%      | 1.4%              |
| Drug Dealing                                 | 80.6%      | 16.7%     | 2.7%              |

Source: Primary Survey Data

## **6.6 PERCEPTION OF LAW AND ORDER IN BEKKERSDAL: RISK FACTOR**

Households were asked to state their perception of law and order in the community with regards to disaster risks and policing in general. Overall, the results varied with 52% of households indicating that there is law and order, such as police forums and various

other committees for disaster risk management, however when it comes to implementation and assistance they are often very late. Likewise, with personnel responsible for disaster related issues such as firefighters, community health workers and ambulance, even though they respond, their response is viewed as always significantly delayed. For these committees to have a meaningful impact, households indicated that more training is needed (personnel and by those committees), including the training of households and the community at large on disaster mitigation. A household's empowerment initiative to enable households to assist each other in times of disaster events was also suggested. Generally, households felt that the police were not doing enough in combating crime while the law and order reporting of crime is not always reliable. 48% of households indicated that there is no law and order in Bekkersdal. Table 16 below show direct responses from the households, with emerging theme that the majority of households in Bekkersdal perceive that there is law and order, although it is often late.

**Table 16 Direct Responses by Household on Perception of Law and Order in Bekkersdal**

|                                                                                                                       |
|-----------------------------------------------------------------------------------------------------------------------|
| Respondent #21 "Response from the police and disaster practitioner/committees is often late and poor"                 |
| Respondent #99 "Crime is very high and not getting help from the police"                                              |
| Respondent #310 "There are disaster forums, police officers, community health workers"                                |
| Respondent #670 "Community is ignorant of sewerage system and dumping areas, even if there are laws restricting that" |
| Respondent #748 "Street committee offer a place to stay when there is a disaster"                                     |
| Respondent #799 "There are not enough fire fighters, ambulance and security"                                          |
| Respondent #101 "There is one police station and that is not enough"                                                  |
| Respondent #911 "People need to be educated on what to do when there is a disaster"                                   |

## **6.7 SOCIAL STRUCTURES FOR DISASTER RELATED RISKS**

Scholarly literature reviewed in chapters 2 and 3 of the thesis view social structure (composition of individuals and organisations) as one of the measures that can be used in mitigating (preparation, prevention and coping with) the effects of disaster related risks and reduce the vulnerability of households. Thus, awareness of these disaster related structures and community participation is critical at the disaster risks reduction phase and mitigation. Therefore, households were probed to indicate any social structures in place for or to address disaster related risks in the area and whether these structures serve their purpose. The results were mixed, with the majority of households at (67%) indicating that social structures exist in Bekkersdal, but do not address the disaster related risks present in the community. These structures are in the form of community health workers, police forums, disaster risk management committees, community ward based patrollers, clinics, schools, churches and police station. A third (33%) of the households indicated that there are no social structures in place that deal or address disaster related risks as these were demolished during service delivery protests to express discontent in service deliveries. As such households don't know whom to call when disaster strikes.

Table 17 below is a summarised version of the household responses. What can be gleaned and emerging from household reactions is that the current structures in place as mentioned by households (clinics, schools, churches and police station) are currently used as structures or places of safety for disaster related risks, yet that is not their primary function, highlighting the need for proper structures to be in place that should be dedicated for disaster related risks.

**Table 17 Direct Quotes on Bekkersdal Social Structures**

| Respondents #                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>• #5'Police forums, disaster management forums and community health workers exist'</li> <li>• #89'Paramedics for emergency and police forum for crime, fire fighters available, though they are a few'</li> <li>• #254'In some instances, churches and schools are used as a place of safety when there are disasters'</li> <li>• #332'Disaster risk officers, in some cases go door to door teaching households about dangers of fires and measures that should be in place'</li> <li>• #451'Clinics, schools and churches used as structures when disaster related risks takes place in Bekkersdal, other structures were destroyed by community during service delivery protests'</li> <li>• #551'We hear of the structure, but we have not seen any to date'</li> <li>• #611'No social structure in Bekkersdal, we destroy everything in Bekkersdal, we destroy hall, we destroy our community fire fighters',</li> <li>• #731'No social structure in place in Bekkersdal, we hear but have not seen it'</li> </ul> |

## 6.8 COPING MECHANISMS: DISASTER RISKS

Households were asked to indicate measures they used to cope with the disaster risk and their associated impacts. The graph in Figure 43 shows the different measures households use to cope with disasters. Thirty-five percent (35%) of the households indicated that they used cash at their disposal to deal with disaster impacts. Whilst (65%) of households do not have any means to cushion themselves against disaster events. In addition, only about 13% of households had assets to sell so as to cushion themselves against these risks. About 30% of the households either borrowed or received aid, while 26% moved to places of safety, meaning the rest of Bekkersdal households are left vulnerable when disaster related risks occur as they do not have means. Literature as discussed in Chapters 2 and 3 of the study advises that caution

should be exercised when households use measures such as spending cash, borrowing or selling assets. For instance, while households can use their savings/ borrow or move to other places, the resources at their disposal become depleted and as such, they increase their indebtedness.

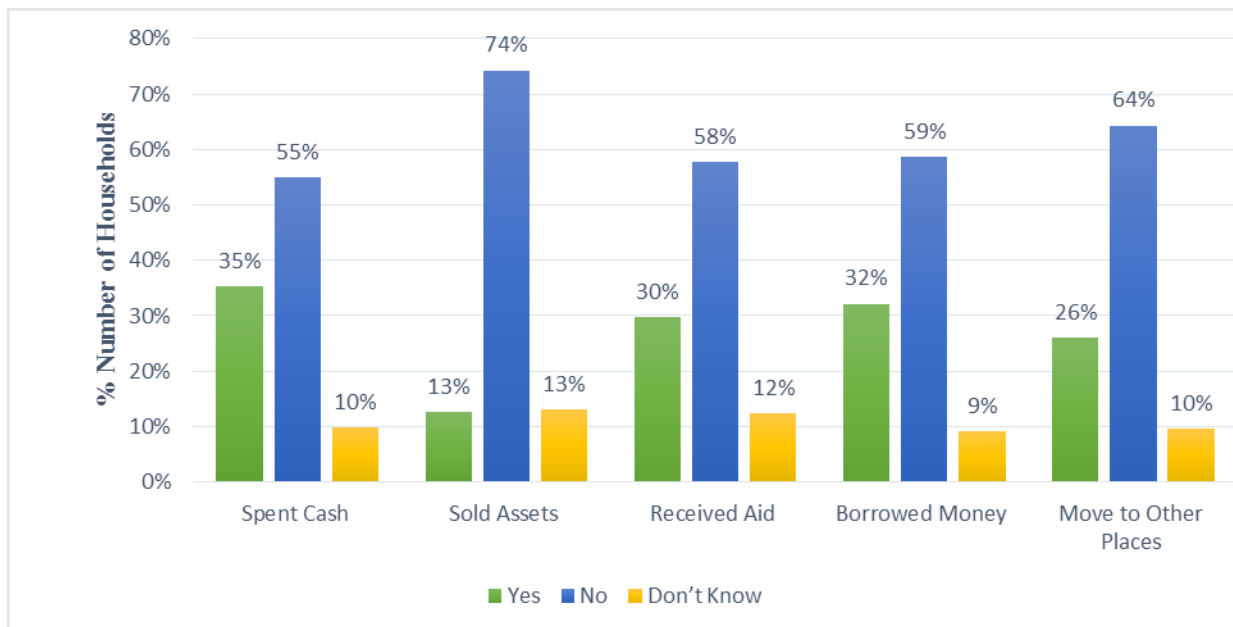


**Figure 43 Type of Measures Used by Households**

Source: Primary Survey Data

## 6.9 HOUSEHOLD VULNERABILITY LEVELS: GROUP

In identifying vulnerability levels of households by groups, households were asked to evaluate their vulnerability to disaster shocks. They were asked to use a Likert scale to rate their vulnerability. The rating ranged from high to low vulnerability levels. Table 18 below summarises the different vulnerability levels of Bekkersdal households. The findings show that children under 18 years were highly vulnerable in the area at about 68%, followed by women and immigrants at 64% and 65%, respectively. Also, 61% of the elderly considered themselves vulnerable, while 59% of people with disabilities felt the same. These results are in line with what has been observed in literature as discussed in the preceding chapters, where the most vulnerable groups to disaster related risks were identified as mainly women, children, the elderly, people with disabilities and immigrants (Barry *et al.*, 2011, Vink & Takeuchi, 2013, Usamah, 2014, Abunyewah *et al.*, 2018, McNamara & Clissold, 2019). These groups often face

difficulties in accessing the resources to cope with disaster risk impacts and as such would require additional assistance or support.

**Table 18 Household Vulnerability: Group**

| <b>Vulnerable Groups</b> | <b>High<sup>15</sup></b> | <b>Medium<sup>16</sup></b> | <b>Low<sup>17</sup></b> |
|--------------------------|--------------------------|----------------------------|-------------------------|
| Children                 | 68.1%                    | 17.7%                      | 14.2%                   |
| Women                    | 63.8%                    | 24.2%                      | 12%                     |
| Men                      | 14.0%                    | 62.6%                      | 23.4%                   |
| Elderly People           | 61.1%                    | 23.1%                      | 15.8%                   |
| People with disabilities | 59.0%                    | 20.7%                      | 20.3%                   |
| Immigrants               | 64.9%                    | 15.5%                      | 19.6%                   |

Source: Primary Survey Data

## 6.10 RESPONSE AND RECOVERY MEASURES

Households were further asked to identify the type of measures used by their municipality to respond to disaster risks. Table 19, below, summarises the different response and recovery measures. The responses range from disaster information dissemination, emergency response, early warning systems, relief measures as well as rehabilitation of assets. The results indicate that over 50% of households indicate that the municipality does not have a predetermined evacuation plan nor an early warning system in place. Over 40% of households' point to the non-availability of disaster information dissemination, emergency response plans, community disaster risk practitioners as well as risk assessments as major drawbacks to the district's responsiveness to disaster related risks in Bekkersdal. In terms of the services/ programmes on rehabilitation or replacement of infrastructure services /subsidisation for households the scores were very low at 37% and 39% respectively, an indication that the majority of households are left on their own and as such become vulnerable. Literature as elaborated in Chapters 2 and 3 strongly recommended government

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<sup>15</sup> High Vulnerability = Households who are in critical state and would need expert assistance to recover from the impacts of the shocks.

<sup>16</sup> Medium Vulnerability = Households that require some level of external assistance to overcome the given shock.

<sup>17</sup> Low Vulnerability = Households that can adjust to given shock without needing significant external support.

intervention and community involvement and participation in terms of response mechanisms to disaster related risks, so that the community is aware of response measures in place and what they should be doing so that it becomes a collective effort. Further, government and the community need be collectively involved in rehabilitation efforts as they look beyond the return to status quo towards long term measures that are sustainable and assist in addressing root cause of household vulnerability.

**Table 19 Response and Recovery Measures**

| <b>Response and Recovery Measures</b>             | <b>Yes</b> | <b>No</b> | <b>Don't Know</b> |
|---------------------------------------------------|------------|-----------|-------------------|
| Predetermined Evacuation Plans                    | 15%        | 51%       | 34%               |
| Disaster Information Dissemination                | 26%        | 46%       | 27%               |
| Emergency Response Plans                          | 37%        | 44%       | 19%               |
| Early Warning Systems in Place                    | 25%        | 52%       | 23%               |
| Community Disaster Risk Practitioners             | 34%        | 42%       | 24%               |
| Risk Assessment                                   | 31%        | 45%       | 24%               |
| Creation and Provision of Shelters                | 31%        | 45%       | 24%               |
| Creation and Provision of Food                    | 46%        | 34%       | 20%               |
| Creation and Provision of Medical Attention       | 50%        | 31%       | 19%               |
| Rehabilitation of Assets: Infrastructure Services | 37%        | 38%       | 25%               |
| Rehabilitation of Assets: Subsidisation of Houses | 39%        | 38%       | 23%               |

Source: Primary Survey Data

## **6.11 DISASTER PREPAREDNESS AND PREVENTION MEASURES (MITIGATION)**

Literature highlights that mitigation measures are critical and need to be adopted when addressing issues related to disaster risks as they prevent or reduce the impacts related to disaster risk. These measures include awareness/preparedness and early warnings systems that need to be in place so as to reduce negative impacts caused by disaster risks. In the Bekkersdal, households were asked to identify the type of measures they

used to mitigate disaster risk related events in their area/ household. About 69% of the households indicated the measures they use to mitigate disaster risks. These included use of fire extinguishers, water, soil, whistle blowing, borrowing money from the bank, emergency numbers to call, moving to places of safety, flush toilet systems, spending cash/savings, planting trees, providing shelter and food, fireballs, receiving aid, selling some assets, police forums, and calling emergency numbers/police. In 31% of the households, response ranged from 'don't know', 'none', 'do not have mitigation measures', and 'don't know what mitigation measures are and what to do to mitigate disaster risks. What is clear and emerging from the household responses, is that the measures mentioned are response measures which occur after a disaster has taken place, as well as traditional methods such as the use of soil and water. In terms of mitigation measures, there is none done or known by the households of Bekkersdal and as such they become vulnerable to disaster risks that could have been reduced or prevented if mitigation measures were in place, known to them, available and used. Table 20 below are the direct responses on mitigation measures used by households.

**Table 20 Direct Responses by Household on Mitigation Measures**

| Respondent #                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>▪ #35 'Health education, door-door campaigns ward, counsellors and community ward based to give information to the community for prevention and to deal with early disaster risk'</li> <li>▪ #418 Legal connection of electricity'</li> <li>▪ # 265 'Sell some assets'</li> <li>▪ # 149 'Spend cash/savings'</li> <li>▪ #153 'Borrow money from banking or do gambling'</li> <li>▪ # 346 'Need to have water and bucket or fire extinguisher'</li> <li>▪ # 473 'Call emergency number or police'</li> <li>▪ #616 'Have a bucket full of water and fire bell'</li> <li>▪ #689 'Move to the other places this place is not safe for our life or health'</li> <li>▪ #717 'Borrowed money from mashonisa (loan sharks)'</li> <li>▪ # 815 'Put bricks on top of the shacks to protect roof from getting away if</li> </ul> |



there's heavy rains'

- # 943 'Have a tap for water in case of fire otherwise we depend on calling for help'
- # 578 'Blow the whistle, call the police and fire fighters'
- #457 'Nothing, if municipality is doing nothing'
- # 551 'No prevention as we know nothing about it'
- # 843 'No prevention, don not have money for insurance'

## 6.12 FIELD WORKERS OBSERVATIONS/NOTES

This section briefly presents the views, observations, challenges and experiences by field workers when administering the questionnaire to the households. Thirty-two percent (32%) of the fieldworkers reported no challenges/problems observed or experienced whilst 68% reported or observed some challenges. These were summarised as follows: parents staying at home with no source of income; people being sick; parent staying with their children and surviving on pension grant; elderly people leaving alone without assistance from family or community; unemployment and poverty; delivery of basic services not taking place in the area (no electricity, refuse removal not collected, no water or tap in the yard and no flushing toilet); households reside in shacks no proper houses/brick houses; and household lack awareness on disaster risk management/ related issues including how they ought to address the risks. Including crime; prostitution and drugs; teenage pregnancy; people being sick; whilst dust; pollution; water pollution; and shack dwellers living near the dumping sites are the order of the day. Some households indicated that they have been voicing their concerns over the years without any assistance and do not know whether and how the present research would be of assistance on various issues they have raised over the years. Yet other observations were of households being angry towards councillors as they have been promised improved service delivery, but nothing has happened, with households being desperate for better life. Emerging from these observations is the dire and gloomy scenario of Bekkersdal community, leaving in hopelessness and fear, with no social cohesion, requiring urgent assistance in a multidisciplinary approach (government, private sector, NGO's, community support). Table 21, are the direct quotes of what was observed or experienced by fieldworkers:

**Table 21 Direct Quotes by Fieldworkers Observations and Notes**

| <b>Parent staying with her orphans and there is no source of income</b> |                                                                                                                                                                                                                                                                                   |
|-------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 6                                                                       |                                                                                                                                                                                                                                                                                   |
| # 22                                                                    | 'Most of the people are sick, children have skin problems because they are playing in the sewerage running'                                                                                                                                                                       |
| #468                                                                    | 'Place is surrounded by dumping sites, with children also playing in the dumping site'                                                                                                                                                                                            |
| # 350                                                                   | 'Elderly people living all alone without any help from relatives or community'                                                                                                                                                                                                    |
| #245                                                                    | 'Households unemployed, there is drug and alcohol problems'                                                                                                                                                                                                                       |
| # 498                                                                   | 'Household need tap, electricity, job, houses they need more security the household said'                                                                                                                                                                                         |
|                                                                         |                                                                                                                                                                                                                                                                                   |
| # 551                                                                   | 'He complained not have water system toilet (flush) but the sewerage is in his yard next to his pit toilet'                                                                                                                                                                       |
| # 537                                                                   | 'They need police around their area, they need ambulance, they need trees and safe place, and they need education about the risk'                                                                                                                                                 |
| # 615                                                                   | 'Household use illegal electricity they don't have ID's, my observation. A household says government is not serious about addressing their problems they say they feel belittled and the government has failed them. They not even bother to meet with them to provide an update' |
| # 468                                                                   | 'I experienced that the household was very worried about the dumping side near our shack. She was worried about their health. She need local municipality to remove that dumping side'                                                                                            |
| #378                                                                    | 'They use illegal electricity by me, they use dirty water to wash their clothes they don't have job, no food, clothes'.                                                                                                                                                           |

## **6.13 DISASTER PRACTITIONER QUESTIONNAIRE<sup>18</sup>**

In addition to the household survey, a questionnaire was administered to the WRDM to gather the views of the officials or disaster practitioners on how they address disaster related risks in Bekkersdal in the RWC local municipality. It is important to note that, the district officer to whom the questionnaire was administered is responsible for disaster related risks in the Bekkersdal area. In terms of capacity/responsibilities, the official mentioned that four officials were responsible for disaster risk management in the WRDM, with each official responsible for a single municipality (Westonaria, Randfontein, Mogale and Merafong).

The questionnaire solicited for both quantitative and qualitative information. In terms of the quantitative aspects; questions such as related to the rating of economic and environmental risks in the Bekkersdal area, the disaster events experienced in Bekkersdal in the last three years, as well as response and recovery measures that the municipality used to assist communities with were posed to the official. On the qualitative part, the questionnaire solicited information related to the social structures in place to address disaster events, the prevention (mitigation) measures used by the municipality to address disaster related risks, whether these measures are part of the IDPs of the municipality, and the challenges experienced by the municipality in relation to disaster risk management. The sections below, discuss findings to the questions posed.

### **6.13.1 Economic and Environmental Risks**

The disaster practitioner was probed by a (yes/no/don know) into whether Bekkersdal, in the RWC of the WRDM has been affected by any of the economic and environmental related risks in the area in the last three years. In summary, the disaster practitioners noted the following disaster related risks; inadequate sewerage treatment<sup>19</sup>, waste disposal challenges, high population density, informal settlements, inappropriate land use, dolomite, sink holes, acid mine water, service delivery protests, land pollution,

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<sup>18</sup> By the Disaster Management Officer- District Office- Randfontein Municipality

<sup>19</sup> See picture below by Herald 2014

earth tremors, crime, flooding, water pollution, dust and illegal electricity connection (which is the cause to shack fires) (see Table 22). The risks highlighted are in line with the findings to the household survey as corroborated by findings in subsections above and by literature reviewed in chapters 2, 3 and 4 of this thesis.

Population density and inappropriate land use were attributed to informal settlements and lack of accommodation which, in turn, have put pressure on delivery of services resulting in limited to non-delivery to basic services such as inadequate sewerage treatment and waste disposal challenges – which can also be argued to be the result of mining related activities. Sinkholes, earth tremors, pollution and dust were attributed directly to negative mining activities. As such, it can be said that the service delivery challenges a rise from the mining activities in the area. However, while risks such as mining and industrial development, uncontrolled veld fires, wetlands destruction, dust, and underground mining do sometimes occur they were not reported to have been experienced in the last three years. It is surprising that the disaster risk practitioner responsible for RWC in the WRDM did not mention mining and industrial development, underground mining, and wetlands destruction, given that these disaster related risks are directly related to the mining activities in Bekkersdal and are environmentally destructive, affecting the community and their livelihoods as discussed in the preceding chapters.

**Table 22 Economic and Environmental Risks**

| <b>Economic and Environmental Risks</b> | <b>Yes</b> | <b>No</b> | <b>Don't Know</b> |
|-----------------------------------------|------------|-----------|-------------------|
| Mining and Industrial Development       |            | X         |                   |
| Informal Settlements                    | X          |           |                   |
| Uncontrolled Veld Fires                 |            | X         |                   |
| Water Pollution                         | X          |           |                   |
| Inadequate Sewage Treatment             | X          |           |                   |
| Waste Disposal Challenges               | X          |           |                   |
| Flooding                                | X          |           |                   |
| High Population Density                 | X          |           |                   |
| Inappropriate Land Use                  | X          |           |                   |

|                            |   |   |   |
|----------------------------|---|---|---|
| Dolomite                   | X |   |   |
| Sinkholes                  | X |   |   |
| Acid Mine Water            | X |   |   |
| Wetlands Destruction       |   | X |   |
| Service Delivery           | X |   |   |
| Land Pollution             | X |   |   |
| Dust                       | X |   |   |
| Underground Mining         |   | X |   |
| Earth Tremors              | X |   |   |
| Crime                      | X |   |   |
| Drug Dealing               |   |   | X |
| Other (illegal Connection) | X |   |   |

Source: Primary Survey Data

### 6.13.2 Social Structures in Bekkersdal

The district officer at the WRDM responsible for disaster related risk in the Bekkersdal, was asked whether there were any social structures in place and whether the structures serve their purpose. The answers were mixed; the disaster practitioner indicated that there were social structures in place to address sudden disaster related risks in the area in the form of volunteers in the community, fire alerts/satellites (which have been destroyed by service delivery protests), and that generally ward councillors together with communities know where to report disaster related incidents, whilst in other instances, communities/households and even councillors do not know these. In terms of whether the structures serve their purpose, the disaster risk practitioner indicated that they do serve their purpose, although at a smaller scale. These results indicate that more needs to be done in terms of social structures being in place and being visible and communicated through, so that members of the community know what to do and where to go, so as to lessen the impact to disaster related risks.

### 6.13.3 Disaster Events in Bekkersdal

On a scale/ Likert scale of 1-3; the disaster practitioner was asked to rank disaster events that have occurred in the area in the last 3 years. Interestingly, fires and disease outbreaks such as cholera (due to water pollution) were mentioned as significant in terms of the occurrence. This was in line with the literature reviewed and results from the household survey. Surprisingly, droughts, sinkholes, windstorms, earthquakes, mining related incidents, flooding and social unrests were indicated as not significant. This could be interpreted as underplay by the disaster practitioner probably because they are an indictment to them, thus denying the existence of these risks maybe a way of suggesting that government mitigation or adaptation measures are working. Table 23 illustrates the responses from the disaster practitioner responsible for disaster related risks in Bekkersdal.

**Table 23 Disaster Events**

| <b>Disaster Events in Bekkersdal</b>           | <b>Very<sup>20</sup><br/>Significant</b> | <b>Significant<sup>21</sup></b> | <b>Not<sup>22</sup><br/>Significant</b> |
|------------------------------------------------|------------------------------------------|---------------------------------|-----------------------------------------|
| Droughts                                       |                                          |                                 | X                                       |
| Sinkholes                                      |                                          |                                 | X                                       |
| Windstorms                                     |                                          |                                 | X                                       |
| Earthquakes                                    |                                          |                                 | X                                       |
| Mining related incidents (dust, earth tremors) |                                          |                                 | X                                       |
| Flooding                                       |                                          |                                 | X                                       |
| Fires                                          |                                          | X                               |                                         |
| Social Unrests (service delivery protests)     |                                          |                                 | X                                       |
| Health Outbreaks (cholera)                     |                                          | X                               |                                         |

Source: Primary Survey Data

<sup>20</sup> Very significant= impact daily,

<sup>21</sup> Significant = Impact weekly,

<sup>22</sup> Not significant= Impact monthly or seldom

#### **6.13.4 Disaster Preparedness and Prevention (Mitigation) Measures**

The disaster practitioner was probed to indicate types of measures used by the municipality in mitigating disaster related impacts and whether these mitigation measures are in integrated development plans (IDPs) of the municipality. The disaster practitioner indicated that there are mitigation measures used by municipalities such as the flood management plans that municipalities have, the awareness campaigns conducted by municipalities, community training on basic firefighting, awareness committees, storm water drainage as well as flood and fire breaks plans. These mitigation measures mentioned above are also included in the IDPs of the municipality but only in the formal areas of Bekkersdal. For instance, in the formal areas of Bekkersdal storm water drainage exists, because proper structures are generally in place. However, in the informal areas, the situation is different as there are no structures in place, and as such, as drainage systems do not exist. Instead pit latrines are used, so the plans exist 'in theory' not for/in practical implementation in the informal areas of Bekkersdal. The response is not surprising, given that the informal settlement of Bekkersdal has been built on inappropriate and unstructured land not suitable for accommodation and, as such, basic services are limited and close to non-existent in the area. Issues of lack basic service delivery have become a norm in the area, together with challenges related to flooding due to lack of drainage systems. Thus, when coupled with mining related impacts, the area has been described as a ticking bomb about to explode and become a disaster.

#### **6.13.5 Response and Recovery (Adaptation Measures)**

In terms of the response and recovery measures, a question was posed to the disaster practitioner to indicate the types of response and recovery measures used by the municipality in addressing/ dealing with disaster related impacts in the community of Bekkersdal. Table 24 summarises the responses to the different measures. Responses indicate that there are predetermined plans at the district level, that are used to offer assistance to the Bekkersdal community when disaster strikes and these include schools, clinics, crèches and hospitals. In terms of disaster information dissemination, volunteers and text messages have been used. Emergency response plans exist, including early warning systems. It should be noted though that in these responses,

provision of shelters for households is availed through schools, clinics and creches, an indication that the municipality does not have dedicated measures in place on provision of shelters.

In addition, it was indicated that community disaster risk practitioners exist in the form of community volunteers that are spread across depending on the risk. For instance, when there is a fire, the community volunteers would be involved in basic firefighting tasks. Risk assessments methods exist and are conducted in areas where a disaster has occurred. In terms of relief measures, it was indicated that they are in the form of shelters, food and medical attention. An example was given of tents provided for a period of 21 days and the provision of food. Furthermore, other relief measures are provided and accessed through the social development office, while health interventions are accessed through the emergency management services (EMS) and clinics. On the replacement and rehabilitation of assets such as infrastructure, it was indicated these services were not available at the local level as it is a provincial responsibility. In addition to non-availability of rehabilitation services at the local level, the disaster practitioner further stated that whilst the function of rehabilitation of assets falls within the provincial responsibility, “it takes long and for municipalities to rehabilitate the infrastructure services affected by disaster related risks, it requires the permission of a province”. An indication that communities are left on their own to restore their status quo. Another avenue mentioned as a measure to response and recovery were disaster response grants, available at district and local levels to address disasters.

**Table 24 Response and Recovery Measures**

| <b>Response and Recovery Measures</b> | <b>Yes</b> | <b>No</b> | <b>Don't Know</b> |
|---------------------------------------|------------|-----------|-------------------|
| Predetermined Evacuation Plans        | X          |           |                   |
| Disaster Information Dissemination    | X          |           |                   |
| Emergency Response Plans              | X          |           |                   |
| Early Warning Systems in Place        | X          |           |                   |
| Community Disaster Risk Practitioners | X          |           |                   |
| Risk Assessment                       | X          |           |                   |
| Creation and Provision of Shelters    | X          |           |                   |



|                                                   |   |   |  |
|---------------------------------------------------|---|---|--|
| Creation and Provision of Food                    | X |   |  |
| Creation and Provision of Medical Attention       | X |   |  |
| Rehabilitation of Assets: Infrastructure Services |   | X |  |
| Rehabilitation of Assets: Subsidisation of Houses |   | X |  |

Source: Primary Survey Data

### 6.13.6 Challenges and Opportunities: Disaster Related Risks in Bekkersdal

The disaster practitioner responsible for managing and addressing disaster related risks in Bekkersdal was asked to indicate whether there are challenges and opportunities faced by municipalities in managing/addressing disaster related risks in the Bekkersdal area.

Challenges highlighted include the following: pressures at municipal level to address disaster related issues were highlighted. Human resources/capacity issues were noted by the official, for instance, the disaster practitioner mentioned that in the whole of West Rand District (Mogale, Randfontein, Merafong and Westonaria), only four officials are responsible for disaster related events. All four officials are based at the district level. There are no disaster practitioners at municipal level. At municipal level there are volunteers who are not paid/ not even a stipend. There is also political interference in disaster risk management, which in some instance results in plans not being executed properly. The respondent highlighted the limited prevention and mitigation, response and recovery strategies in place. There is a lack of basic services, especially in the informal settlements. For example, pit latrines are used as there are no drainage systems. Illegal electricity connections which are the cause of many fires in Bekkersdal were also highlighted. The non-timely rehabilitation and replacement of assets (infrastructure/ houses) after a disaster has occurred were cited in this vein. The challenges highlighted by the disaster practitioner in Bekkersdal corroborate the findings from the household survey alluded to earlier in this study as well as findings from the literature reviewed in the preceding chapters.

On opportunities, the disaster practitioner highlighted that there is a need for disaster risks volunteers in each local municipality, with an expanded scope. Currently, it was indicated that there are disaster risk practitioners who are volunteers who assist communities where they can. However, the disaster practitioner indicated that the method is not sustainable as volunteers are available on *ad hoc* basis when the disaster events occur, and as such, an institutionalised method is required so that there is continuation and longevity. Also required would be stipends for the volunteers to incentivise, encourage and motivate them to do more for the community on issues related to disaster risks.

In terms of the limited mitigation measures in place at the municipal, the disaster practitioner indicated the need for the institutionalisation of these measures at the municipal as well as the provincial levels of government. Likewise, there was need for availability of funds/ budget dedicated for municipal disaster related risks which should be part of the IDPs for the municipalities. Lastly, the disaster practitioner indicated the need for a coordinated approach with NGO's on disaster risk related issues on a continuous basis, instead of the *ad hoc* engagement and collaboration approach that is currently in place.

## **6.14 HOUSEHOLD VULNERABILITY INDEX AND THE REGRESSION ANALYSIS RESULTS**

This section presents an analysis of vulnerability. It answers the questions: Who is vulnerable and why? On the latter question, determinants of vulnerability are estimated using simple Ordinary Least Squares (OLS) regression. Households heads were classified into three vulnerability categories: highly vulnerable, medium vulnerable and low vulnerability.

Using the vulnerability index scores calculated following FANRPAN (2014)'s methodology, household heads were classified into three vulnerability categories. These ranged from highly vulnerable to very low vulnerability. The sample was divided into 3 categories using the equal interval classification (constant class intervals) as alluded in

Chapter 5. In this classification method, each category contains an equal data interval. To get data intervals, the data range (highest data value minus lowest data value) was divided by the number of classes, three in this case (low<sup>23</sup>, moderate<sup>24</sup> and high<sup>25</sup> vulnerability). The subsections below, discuss the results of the study using the HVI method.

After estimating the class interval, it is added to the lowest score first, then as many times as necessary in order to reveal the number of the predefined classes. The categorisation and proportions of households in each vulnerability category are shown in Table 25.

**Table 25 Household vulnerability status of the households**

| <b>Vulnerability category</b> | <b>HVI value range</b> | <b>Situation of household</b>                                                                                                        | <b>% of households</b> |
|-------------------------------|------------------------|--------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| Lowly Vulnerable              | 0 - 49                 | Households that are coping and when in a vulnerable situation, they are able to cope.                                                | 42%                    |
| <b>Moderately Vulnerable</b>  | 49.1 - 61              | When hit hard by a shock, the household needs urgent but temporary external assistance for it to recover.                            | 51%                    |
| <b>Highly Vulnerable</b>      | 61.1 - 73              | Emergency level household-the equivalent of an intensive care situation-could be resuscitated only with the best possible expertise. | 7%                     |
| <b>Total</b>                  |                        |                                                                                                                                      | 100%                   |

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<sup>23</sup> Households that are coping and when in a vulnerable situation, they are able to cope.

<sup>24</sup>When hit hard by a shock, the household needs urgent but temporary external assistance for it to recover.

<sup>25</sup> Emergency level households (which is the equivalent of an intensive care situation) that need to be rescued with best possible expertise.

### 6.14.1 Household Vulnerability Status: HVI Overall Vulnerability of Households

The distribution of household heads in terms of vulnerability are shown in the last column of Table 25 and Figure 44. Overall, in the sample surveyed, the HVI results indicate that 58% of the household heads are vulnerable; divided into 7% being extremely vulnerable and 51% moderately vulnerable. Figure 43 shows that 42% are in the low vulnerability category. In the following subsections, vulnerability indices (HVI) were further interrogated by gender, education, marital and employment statuses.

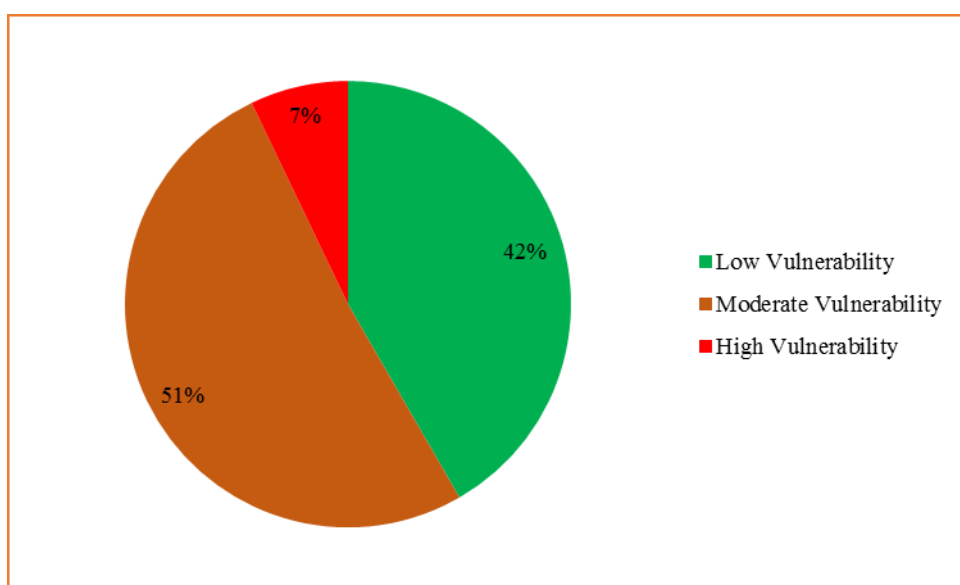


**Figure 44 Household head vulnerability status**

Source: Primary Survey Data

### 6.14.2 Household Head Vulnerability Status by Gender

Figure 45 below indicates that in Bekkersdal women are more vulnerable than men by almost five percentage points. This result is not surprising and is similar to what the quantitative analysis reported in the earlier section. This result also conforms to what is found in literature as well as other socioeconomic and environmental indicators that show gender disparities, with women carrying the bulk or being highly exposed to disaster risks than the males. As such, any disaster related impacts that takes place in the area, women should be given a priority.

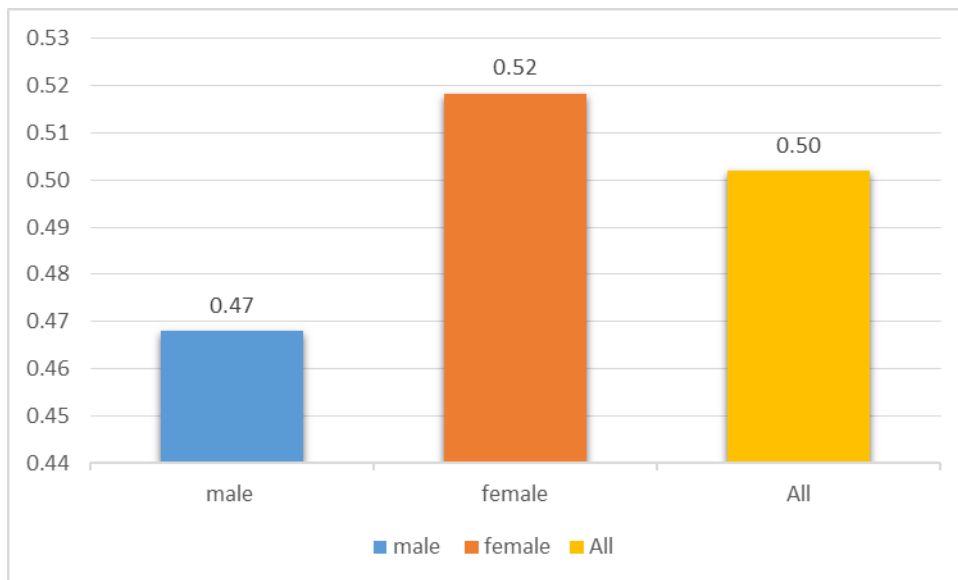


**Figure 45 Household Vulnerability by Gender**

Source: Primary Survey Data

#### 6.14.3 Household Head Vulnerability Status by Education

The Household Vulnerability Index by education indicates that household heads that are illiterate are more vulnerable with an index of 0.56 in comparison to other households with professional/ vocational training that have an average index of 0.47, and those with university level training whose average HVI index was 0.44, as shown in Figure 46. As observed in various studies, households with less education are more vulnerable than those with higher levels of education, which was the case with HVI at (0.52) for primary education levels versus the university levels at (0.44) respectively. Less educated households are more vulnerable as they have limited incomes at their disposal to cushion themselves from the impacts of disaster related risks, as discussed elsewhere in this study and the preceding chapters in the thesis.

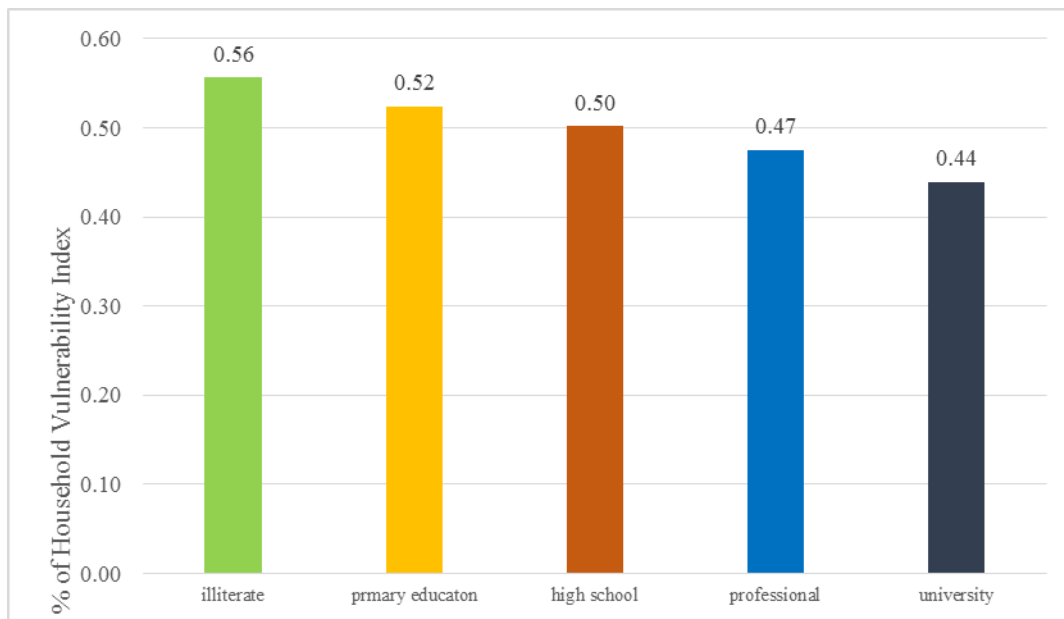


**Figure 46 Vulnerability Status by Education**

Source: Primary Survey Data

#### **6.14.4 Household Head Vulnerability Status by Marital Status**

The HVI was also disaggregated by marital status for the Bekkersdal community. The results in Figure 47 showed that married and cohabiting households were less vulnerable compared to the divorced, single, widowed and separated. The average vulnerability index for married and cohabiting participants were 0.49, while widows and divorced households had an average of 0.51, and single and separated participants had scores of 0.50. The vulnerability index for single, divorced or separated household heads can be attributed to broken families as alluded to by Koen *et al.*, (2017), which is one of the factors that hinder wellbeing of Bekkersdal households. Therefore, these results imply that when a disaster related event occurs, priority should be given to divorced, single and separated individuals, as previously discussed in this thesis.

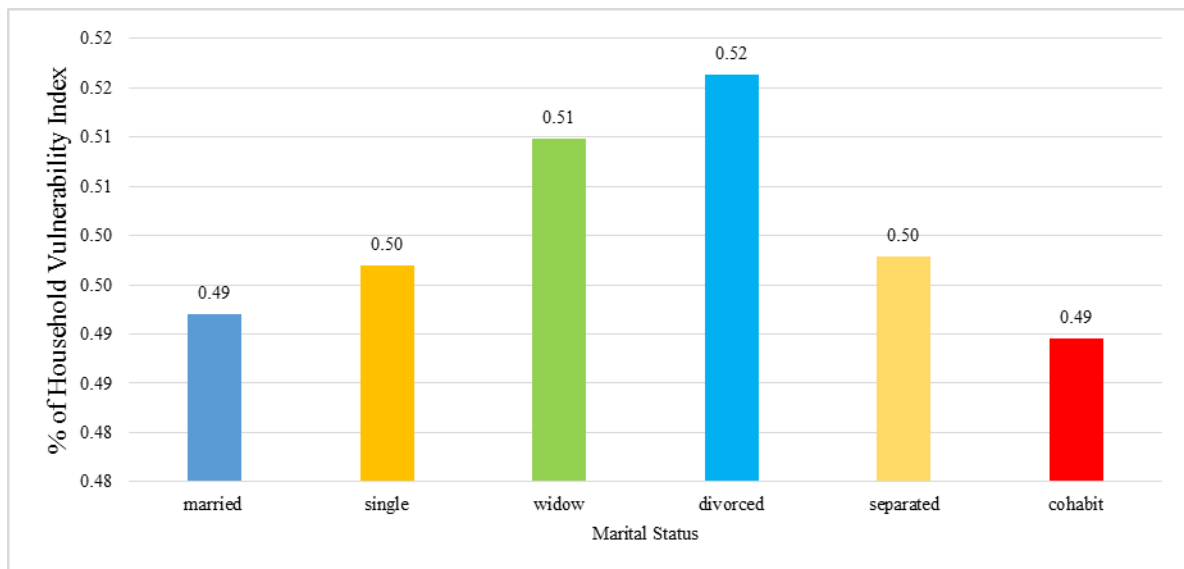


**Figure 47 Household Marital Status**

Source: Primary Survey Data

#### **6.14.5 Household Head Vulnerability Status by Employment Status**

Employed people are less likely to be vulnerable when compared to the unemployed (Figure 48). The results of the present study are in line with literature as the unemployed participants were found to be more vulnerable (average index of 0.51) compared to their employed counterparts with an average index of 0.49. Thus, from a policy perspective, priority should be given to the unemployed when a disaster strikes as elaborated earlier in this thesis.

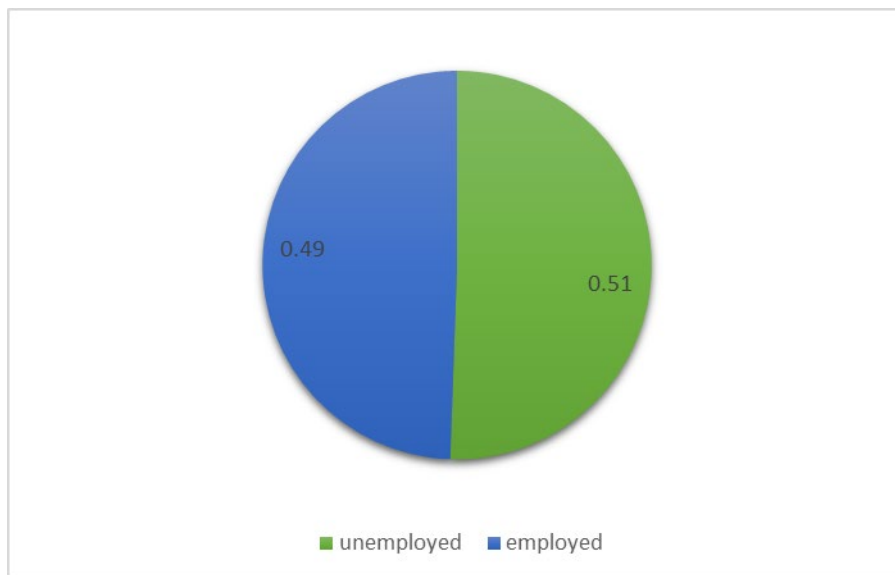


**Figure 48 Household Vulnerability Levels by Employment**

Source: Primary Survey Data

In summary, the results on household's vulnerability indices above, showed 7% of Bekkersdal are extremely vulnerable and slightly over half are moderately vulnerable. Disaggregating the levels of household vulnerability by gender, education, marital and employment status shows that women are more vulnerable than men. Less educated individuals are more vulnerable than educated ones. Similarly, the unemployed are more vulnerable than the employed. Lastly, marital status results as indicated, showed that married and cohabiting households were less vulnerable than single and divorced individuals. Overall, the study results support the findings in literature which suggest that women, unemployed, divorced, separated and widowed individuals are more vulnerable than men, employed, married and cohabiting household heads, respectively.

## 6.15 FACTORS INFLUENCING HOUSEHOLD HEADS VULNERABILITY: REGRESSION ANALYSIS RESULTS

The possible determinants of vulnerability of the household head are many. Using a simple ordinary least square regression, this study isolated key drivers of household vulnerability.

$$HVI = f(X)$$



Where HVI is household vulnerability index and  $X$  refers to explanatory variables that include household head's level of education, age, marital status, gender, infrastructure (represented by access to electricity), asset ownership, access to social networks and access to basic services (represented by access to sanitation). The results are shown in Table 26 below. The model passes all the diagnostic tests and the coefficients carry the right and expected signs. The adjusted  $R^2$  is 91%, indicating a high explanatory power of the model.

The results in Table 26 below suggest a significant but negative relationship between education and vulnerability. An increase in the number of years of education by 1% reduces vulnerability by 0.09%. The result implies that, in order to minimise vulnerability of the Bekkersdal community, education is a key lever. Age exhibits a positive and significant relationship with vulnerability (0.04%). It means older people are more vulnerable. That was not surprising considering that many older people are not engaged in meaningful economic activity (as they often rely on social grants). It is therefore important for interventions by the municipality and government to target older people.

Marital status (0.01%) and gender (0.04%) variables also carry significant and positive coefficients. These two results suggest that one's gender or one's marital status has a significant bearing on one's vulnerability. Thus, it is important for interventions designed to ameliorate the vulnerability to take into account gender and marital status of the household heads. As noted in the descriptive analysis of this chapter (section 6.2.2, on marital status) women and divorced individuals are more likely to be vulnerable compared to men or married people.

Other variables that explain vulnerability of household heads were infrastructure and access to basic services. Access to infrastructure and basic services reduces vulnerability quite significantly. That is, the more households possess those resources the less vulnerable they become, (as outlined in descriptive analysis above), therefore it is important for the municipality to provide the community with sound infrastructure and basic services in order to minimise their vulnerability. Investment in infrastructure and improving access to basic services are key imperatives for the municipality and government if vulnerability of communities is to be minimised. Thus, in Table 26 there

are negative coefficient signs for infrastructure, assets, social networks and basic services, respectively.

**Table 26 Regression Analysis: Factors Influencing the Vulnerability of Household Heads**

| Independ Variable   | HVI         |                |
|---------------------|-------------|----------------|
| Dependant Variables | Coefficient | Standard Error |
| Constant            | 0.1699      | 0.0077         |
| Education           | -0.0927***  | 0.0012         |
| Age                 | 0.0440***   | 0.0016         |
| Marital Status      | 0.0009*     | 0.0005         |
| Gender              | 0.0441***   | 0.0010         |
| Infrastructure      | -0.0055***  | 0.0007         |
| Assets              | -0.0021**   | 0.0013         |
| Social Network      | -0.0016     | 0.0011         |
| Basic Services      | -0.0037***  | 0.0011         |
| Diagnostic Tests    |             |                |
| Number of obs.      | = 941       |                |
| F (8, 932)          | = 1231.08   |                |
| Prob. > F           | = 0.0000    |                |
| R-squared           | = 0.9135    |                |
| Adj. R-squared      | = 0.9128    |                |
| Root MSE            | = 0.0154    |                |

\*\*\*, \*\*, \* Denote statistically significant at 1%, 5% and 10%

Source: Primary Survey Data

To summarise, the above regression results, the analysis indicates that vulnerability can be explained by, among other variables, education, marital status, age, access to infrastructure and basic services. For instance, in the analysis, an increase in education has an inverse relationship with vulnerability. That is, the more the years of education, the lower the levels of vulnerability as education acts as an asset that cushions the household against disaster impacts. Age and marital status had a positive effect, that is, the older the household head is, the higher the vulnerability, and those who are

married experience the effects of vulnerability less than their counterparts who are single. On infrastructure assets, basic services and social networks, as the theory and literature states, the more households possess or have access to these resources, the less vulnerable they become as they can use the assets to cushion themselves against disaster events.

## **6.16 CONCLUSION**

The chapter presented the general main findings of the study with regards to the vulnerability to disaster risks of households in Bekkersdal. These findings were based on information from a sample of 1 000 households, collected through a survey. The findings of the study were presented in the form of descriptive information, household vulnerability index and regression analysis to isolate the key drivers of vulnerability. The vital demographic indicators show a community that has all the signs of vulnerability or with a likelihood to be vulnerable. The majority of households surveyed were females, either single, widowed, divorced, separated or cohabiting, with low educational attainment levels, whilst unemployment was rife and the majority of households in the area were residing in shacks, engulfed by various ailments; an indication that households in Bekkersdal are vulnerable to various disaster related risks. For instance, it can be argued that the majority of households residing in shacks can be attributed to the unsuitable land (dolomitic land which had a tendency to form sinkholes) found in the area due to mining activities , thus with a shortage of housing, informal settlements were built so that households can be closer to areas of work (mining). Likewise, high unemployment levels have been exacerbated by the closure of the mines that have been occurring in the area. Various health ailments (cholera, skin rash, respiratory) can be attributed to exposure of households to pollution as a result of mine effluents in the area. Interestingly, the various languages spoken other than the South African languages, demonstrated the history and diversity of Bekkersdal as mining opportunities attracted people from neighbouring countries in search for mining jobs.

In terms of livelihood assets that households have, it was clear that in Bekkersdal households have few assets to withstand disaster events. Among household heads there is a thin base of assets such as houses, livestock and businesses. The majority of

households do not own any of these vital assets, and as such, cannot withstand adverse conditions that disaster events bring. Another pointer to greater household vulnerability in the area is the limited access to basic services. Another variable that is known to reduce individual vulnerability are the social protection mechanisms (such as the social networks, insurance, social grants and social food programmes); these were shown to be limited in Bekkersdal. Regarding coping measures used by households in response to disaster related activities, a few respondents spent cash at their disposal, sold their assets, borrowed cash and/or moved to other places. These results suggest that Bekkersdal residents have precarious coping mechanisms, which depletes the resources at their disposal and also increase their indebtedness, rendering them more vulnerable. Regarding which household categories are more vulnerable, the results clearly indicated that children are most vulnerable to disaster risks, followed by immigrants, women, and the elderly. Thus, it is important that these social groupings are prioritised in interventions when there is a disaster.

The majority of the Bekkersdal community do not have access to basic services and vital amenities. Some of the reasons for non-access are linked to the negative mining activities in the area which have resulted in shortages/ limited access to basic services as alluded to above. As discussed in the literature reviewed, issues of informal settlements, inadequate sewerage treatment, waste disposal challenges, service delivery, dust, crime and drugs and strongly related to negative mining activities.

It can be argued that these disaster risk related challenges are attributable to the mining activities that have occurred in Bekkersdal over the years. For instance, the establishment of informal settlements was due to shortage of houses as a result of mining employment in the area and people needing to reside near place of work; the digging of mining resulted in open pits/quarries which in turn were used as waste dumps or illegal waste dumping sites by the households; and basic services became overstretched as they could not cater for all households. Limited service delivery was pronounced for households residing in informal settlements as the area was unplanned and inappropriate, resulting in service delivery protests in the area, whilst the decline in gold mining production meant retrenchments of some of the mine workers who did not have jobs, who after becoming turn to crime causing high levels of crime. Land

pollution, wetlands destruction, inappropriate land use, dolomite, sinkholes, water pollution, underground mining and earth tremors are as a result of negative impact by mining activities that have taken place in the area.

Thus, service delivery becomes a big risk or a secondary risk because of the mining and environmental activities that have and are taking place in the Bekkersdal mining community. In other words, service delivery, is a secondary risk driven by other primary risks (such as the negative mining impacts) making it difficult and impossible to supply basic services in Bekkersdal. Surprisingly, mining development, flooding, uncontrolled veld fires and acid mine water were considered not significant by the participants. These results can be interpreted as implying that households do not associate mining related activities with posing any environmental risks or they are tolerant to these mining activities due to the jobs/employment offered by mining opportunities which results in households being able to take care of their families. Further, the knowledge of mining related risks is arguably and worryingly very low in Bekkersdal. This is a mining town and people around the area are not aware of the risk associated with mining. Evaluating the risks, it is surprising that Bekkersdal population 'don't know' that mining and industrial development, acid mine water and underground mining pose serious risks to the Bekkersdal population and amplify their vulnerability. Overall, it would seem the extensive impact of mining activities on past, present and potential disastrous circumstances on households is underplayed by communities, as these communities are occupied in the struggle to survive.

In addition, results elicited from administration of the disaster practitioner questionnaire in Bekkersdal corroborate what has been found to be the case through the household survey. For instance, the disaster practitioner indicated that disaster related risks in Bekkersdal relate to various forms of service delivery. These include, in the main, the inadequate sewerage treatment, inappropriate land use, crime and service delivery protests, which can be argued to be attributable to the mining related activities (shortage of accommodation, waste disposal challenges also due to mine dumps being turned into dumping sites by households). Sinkholes earth tremors pollution and dust are due to the negative mining activities. However, it is surprising that the disaster risk practitioner responsible for RWC in the WRDM did not mention mining and industrial

development, underground mining, and wetlands destruction. Especially as given that disaster related risks are attributable to the mining activities in Bekkersdal and are environmentally destructive to the community and their livelihoods as discussed in the preceding chapters. Droughts, sinkholes, windstorms, earthquakes, mining related incidents, and flooding were indicated as not significant. It can be argued that some of the reasons for the practitioner to underplay such risks is most probably because they are an indictment to them. Denying the existence of these risks maybe a way of suggesting that government mitigation or adaptation measures are working.

The third part of the analysis in the chapter was the quantification of the vulnerability levels of the Bekkersdal community. An asset/capitals-based household vulnerability index was computed for all household heads. The main assumption or guiding principle of this index is that household heads with limited assets (physical, financial, human, social and natural) are more likely to be vulnerable than those with abundant assets. In a nutshell, the results on the household vulnerability index revealed the following; the majority of households in the community were moderately vulnerable to the disaster related impacts. These indices where further broken down by gender, education, marital and employment status. The results show that females were more vulnerable than men, and those households with low education levels were the most vulnerable, while those household heads that are single, widowed and cohabiting were the more vulnerable compared to their married counterparts. Lastly, was the regression analysis; the results showed that an increase in education has an inverse relationship with vulnerability. That is, the more the years of education, the lower the levels of vulnerability as education acts as an asset that cushions the household against disaster impacts. Age and marital status had a positive effect, that is, the older the household head is, the more vulnerable the household, and those who are married experience the effects of vulnerability less than their counterparts who are single for instance. On infrastructure assets, basic services and social networks terms, as the theory and literature states, the more households possess or have access to these resources, the less vulnerable they become, as they can use the assets to cushion themselves against disaster events. The next chapter, Chapter 7, builds on the general findings on Chapter 6 with an in-depth comparative analysis of the vulnerabilities of households in both formal and informal settings within the Bekkersdal community.

## CHAPTER 7

### THE VULNERABILITY TO DISASTER RISKS: A COMPARATIVE ANALYSIS OF FORMAL AND INFORMAL HOUSEHOLDS

#### INTRODUCTION

The present chapter attempts to answer the main research question by making an in-depth comparative analysis of the vulnerabilities of households in both formal and informal settings within the Bekkersdal mining community. As noted in the preceding chapters of this thesis the findings of the study are based on a survey of the formal and informal households in the Bekkersdal area. Scholarly debate informs that disaster related risks should be understood in terms of people's level of vulnerability, than relying on the physical attributes only. This is due to the fact that households who reside in informal settlements do so, because they are poor or that they do not have the political or economic power to make different choices whilst they are faced with day to day urban challenges of unemployment, poverty and lack of basic services (Abunyewah *et al.*, 2018, Williams *et al.*, 2018). Whereas the well to do people will obviously live in planned formal settlements or areas less susceptible to hazards (mining related incidents) because they have, among others, the economic power to live in such places (Kreps, 1998, Quarantelli, 1998).

Informal situations become intense for communities residing in mining environment (case in point being Bekkersdal community) due to negative environmental impacts caused by mining activities in the form of acid mine drainage, pollution, flooding, environmental degradation and respiratory illnesses (Ackerman *et al.*, 2018, Koen *et al.*, 2017, Nealer 2020). More so for the informal households residing on the unplanned, unsuitable and unsafe environmental conditions, such as dolomitic conditions and sinkholes mining incidents that affects livelihoods and lives of the community (see Figure 49 below). Thus, in understanding community and household vulnerability, the comparison between formal and informal settlements plays a critical role in addressing what are the determinants and what kind of measures should be in place to reduce the

disaster related impacts found in these different communities. More so, given that provision to have adequate housing is enshrined in the Constitution, whereby government must take reasonable measures to provide adequate housing. To that effect, there is a Human Settlements Grant at the provincial government level, with the objective of establishing habitable, stable and sustainable human settlement of all citizens, including those households residing in informal settlements.



**Figure 49 Rain Damaged Roads in Bekkersdal**

Source: Mdluli (2009)

In this chapter the first section provides some descriptive information of both formal and informal households. Essentially, the descriptive information provided in this section compares the characteristics of formal and informal households using various vulnerability indicators, including gender, marital status, employment, education, asset ownership, social protection, disaster risks and coping mechanisms. The second part estimates the household vulnerability through the use of an index called HV1. The index is used to compare the vulnerability of formal and informal households. The last section compares the determinants of vulnerabilities using some econometric regression analysis.



## 7.2 DESCRIPTIVE STATISTICS OF THE BEKKERSDAL HOUSEHOLDS

To understand vulnerability there are certain household characteristics that are key. Individual characteristics such as where they stay, type of household, household's gender, and marital, employment, health, and education statuses, are key in explaining household vulnerability. The next subsections provide a description of these characteristics.

### 7.2.1 Household Type

The present study is based on a survey of 1 000 households in the Bekkersdal area. The majority of households (74.1%) reside in informal areas, while 25.9% reside in the formal areas (Figure 50).

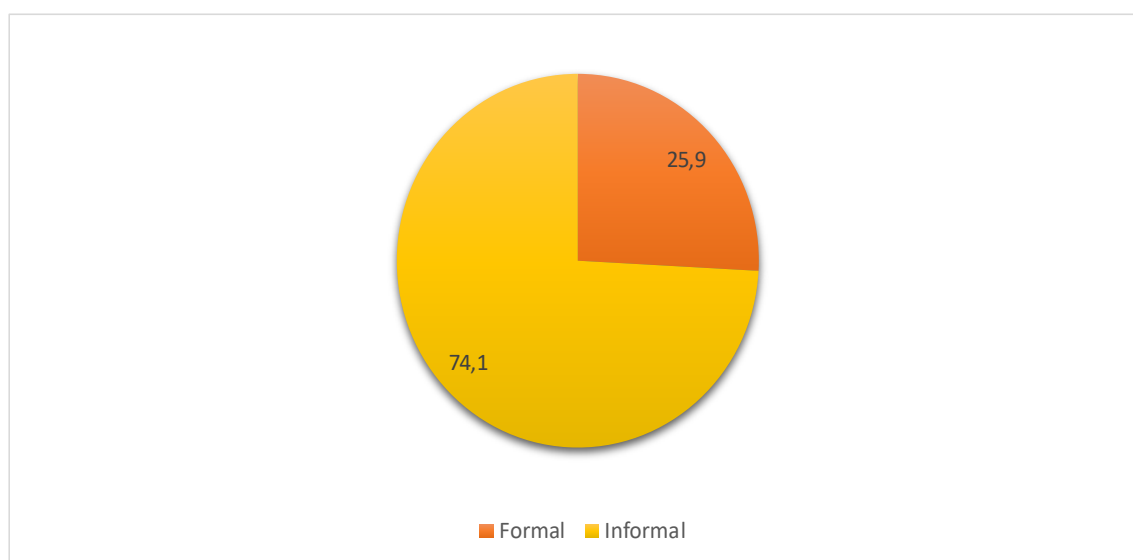


**Figure 50 Household type**

Source: Primary Survey Data

The distribution of the households indicates that the majority of Bekkersdal households reside in areas prone to disaster related risks just as the literature in previous chapters alluded to. Households who dwell in informal settlements are prone to disaster related risks than their counterparts in formal places mainly due to geographical location. As outlined earlier, mining opportunities influence housing conditions such as the informal settlements as a result of migrant labour, the search for jobs, contract uptake of

workers, workers staying closer to areas of work, retrenchments and contract terminations due to closure of some mines – a case in point being the Bekkersdal area. Yet community safety (health, wellbeing and sustainability) in the area is affected by many decades of goldmining activity in the brittle dolomitic Central Basin (see Winde & Stoch, 2010; Koen *et al.*, 2017, Liefferink, 2019).

### **7.2.2 Housing Structure**

Another important asset that assists in minimising vulnerability is the dwelling structure. A brick and mortar structure make the household less vulnerable to many hazardous events compared to a shack. Literature alludes to the fact that households living in houses made of poor materials are more vulnerability relative to households living in houses built of bricks (Shah, 2018, Harrison & Todes, 2020). As alluded to in chapter 4 of this thesis, Bekkersdal came into existence as a result of mining activities, such that the formal settlement could not provide accommodation for all due to the rapid population increase as a result of mining activities, resulting in households residing in the informal settlements which were unplanned, unsafe and uncontrolled (Van Eeden & Diedericks, 2016, Khaba & Van Eeden, 2016). Thus, in the findings of the study, deep seated levels of vulnerability are shown by a disproportionate number of households living in shacks compared to households living in structures made of brick. Figure 51 disaggregates the informal and formal housing by type of structure.

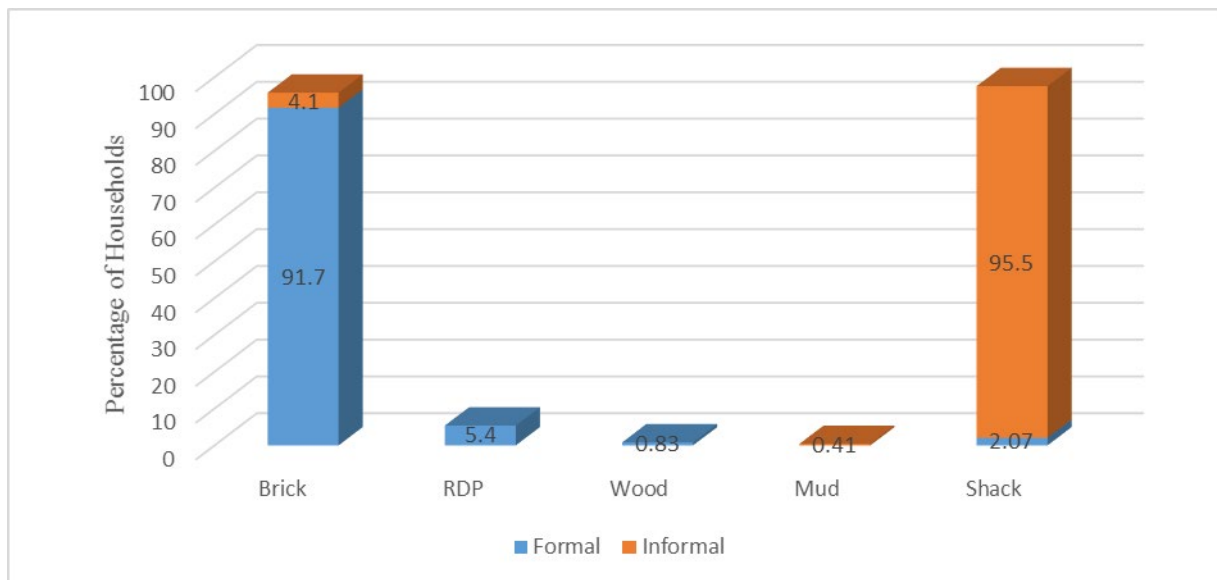


**Figure 51 Type of housing structure**

Source: Primary Survey Data

The results indicate that 91.7% of formal households of Bekkersdal reside mainly in brick houses while 95.5% of informal households reside in shacks; pointing to the vulnerability of informal households in the Bekkersdal area. The area in which one lives is a critical indicator of vulnerability. The literature as alluded earlier, further indicates that informal areas/ squatters live under precarious social conditions and thus should be prioritised with specific interventions that are tailored to lessen their vulnerability, such interventions being joint efforts by the municipality and the mining companies. The rest of housing structure in the formal areas of Bekkersdal are spread between the RDP and wood structures at 5.4% and 0.83%, respectively.

Further, the descriptive analysis in the study included the household demographics by gender, marital status, employment, health status as well as education status. These components or indicators discussed in the subsections below are critical indicators that assist in ascertaining vulnerability levels of households.

### 7.2.3 Household Demographics by Gender Composition

In terms of the demographic profile of the Bekkersdal area, the sample revealed interesting characteristics that have implications on vulnerability. For instance, on

gender, women are the majority in Bekkersdal, in both the informal and formal households, as shown in Figure 52.

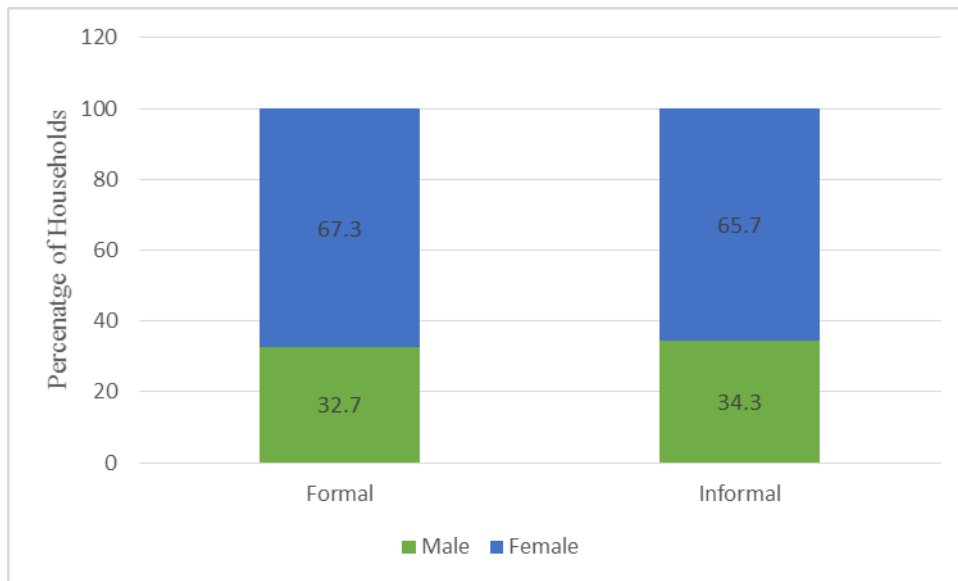


**Figure 52 Gender Demographics**

Source: Primary Survey Data

Women accounted for 67.3% of the formal sample and 65.7% of informal households, respectively. The large proportion of women in both formal and informal samples was very surprising considering that mining areas are traditionally a men's domain. One would have expected men to be dominant in both samples. However, one plausible explanation for this is the timing of the survey. The study was conducted during the day when most men were at work. As the majority of the sample are women, literature is quite clear that women are more likely to be vulnerable than men as discussed in the preceding chapters, and as such, would require more resources when disaster strikes, which would be the case in Bekkersdal as well. One of the reasons for the majority of the sample being women in the study could be the historical profile of Bekkersdal discussed in chapter four, wherein it was indicated that mining still dominates the economy, with the majority of workers absorbed by the mining companies being men.

## 7.2.4 Marital Status

Literature has often underscored the point that single headed households are more vulnerable than their counterparts that are married and when a disaster strikes single people have a limited network to rely upon in order to cope with disaster impacts (Takashi, 2010, Costella & Oyadiya, 2014, Muvuka & Harris, 2019). The distribution of the sample by marital status is shown in Figure 53.

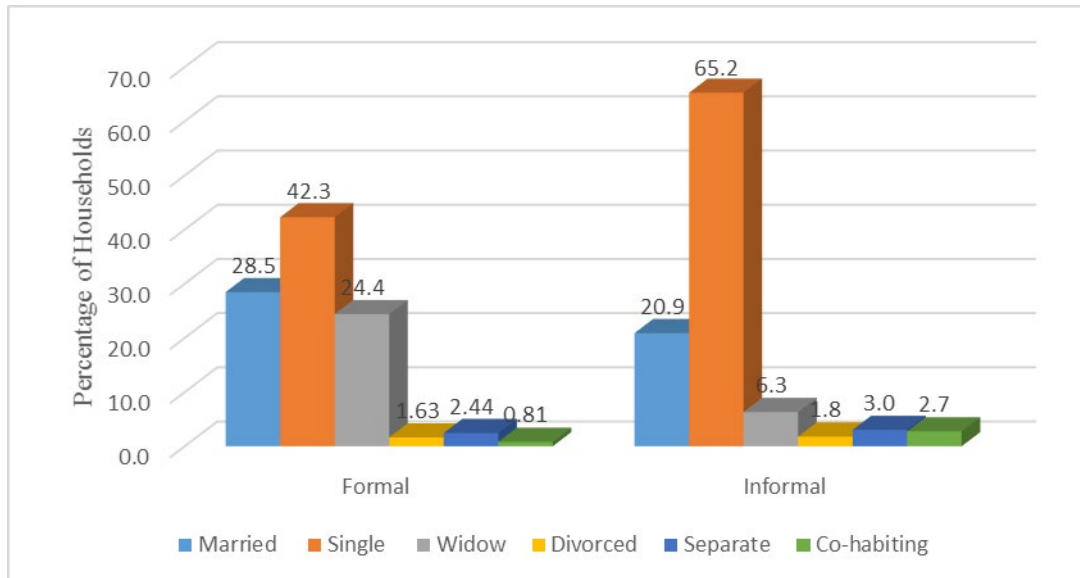


**Figure 53 Household Marital Status**

Source: Primary Survey Data

The results indicate that in the formal area of Bekkersdal, 28.5% of households are married compared to 21% of households that reside in the informal areas; 42.3% of household heads are single in the formal areas compared to 65.2% in the informal areas. Whereas 24% of formal household heads are widowed compared to 6.3% of their informal counterparts; 1.6% are divorced in the formal areas compared to 1.8% in the informal areas. Furthermore, 2.4% of household heads in formal areas are separated compared to 3% in the informal areas; and less than 1% of formal household heads are co-habiting compared to 3% in the informal side. Overall, both the formal and informal households of Bekkersdal are vulnerable to disaster risks due to their marital status, even more so for the informal households by virtue of their geographical, and socioeconomic and environmental circumstances. Some of the factors causing these results can be traced from the historical profile of Bekkersdal discussed in chapter 4 of

the study, where, in the main, people migrated to the Gauteng province in search of employment especially in mining areas in the West Rand. The influx to the area, high population density and limited accommodation resulted in households residing in backyard shacks or eking a living from informal activities.

### **7.2.5 Household Employment Levels**

Results on unemployment levels in Bekkersdal reveal that it is a big challenge in both formal and informal areas. Figure 54 shows that from the sampled households, 40% of respondents were employed in one form or another, compared to only 34% in the informal areas. Unemployment levels are quite high in both the formal and informal areas, at 59.8% and 66%, respectively. This is not surprising given the results by the Stats Survey 2011 and the Community Survey 2016, highlighted in chapter 4 of the study which indicated high unemployment levels in the community of Bekkersdal. The 2011 census indicates that 52% of males and 48% of females were unemployed. Another factor contributing to high levels of unemployment is that Bekkersdal is surrounded by mining activities. Literature states that decline in gold mining activities in the area, retrenchments and closure of mines have also led to high levels of unemployment in Bekkersdal, negatively impacting on the wellbeing of households (Koen *et al.*, 2017, RWC, 2017/18, Ryke *et al.*, 2015, Van Eeden *et al.*, 2009). Thus, households of Bekkersdal have become vulnerable with more resources required in this area as households do not have incomes to cushion themselves from the disaster related risks, especially in the informal settlements.

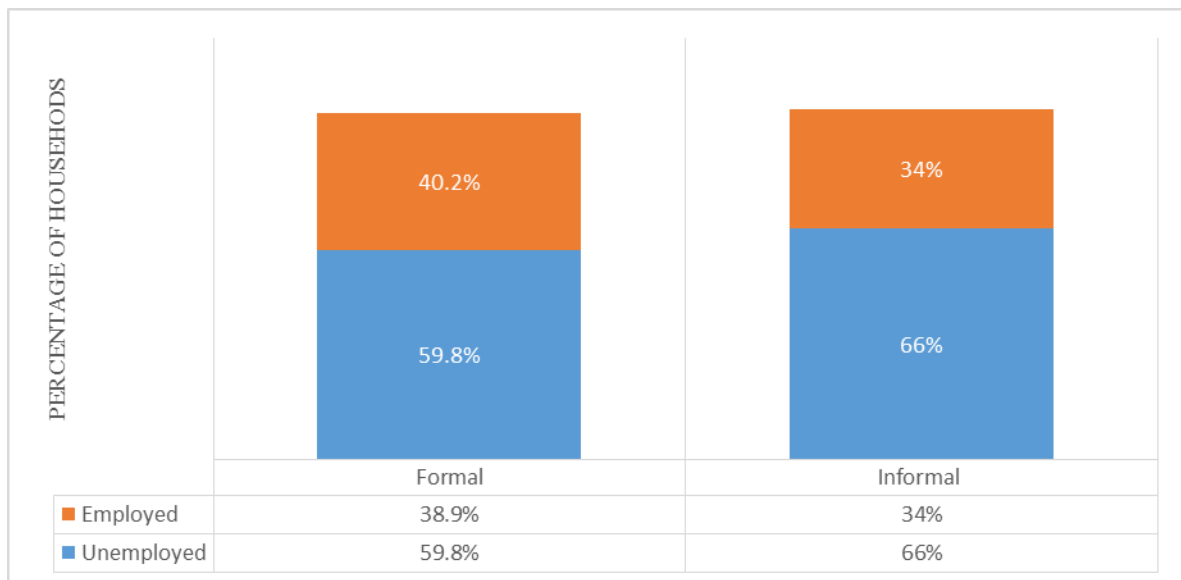


**Figure 54 Employment Status**

Source: Primary Survey Data

### 7.2.6 Household Health Status

The health status of an individual is also one of the measures of vulnerability. Literature states that households who are sickly due to various diseases become more vulnerable to disasters than their counterparts who are healthy. Table 27 indicates the health status of formal and informal households. Both the formal and informal households of Bekkersdal appear relatively healthy at a measured 60% plus for both. The rest of the sample population suffer from high blood pressure in the formal side (23.3%) interestingly in comparison to the informal area (10%), followed by HIV/AIDS at 17% in the informal areas of Bekkersdal in comparison to 4% in the formal areas. Diabetic diseases are common in the area at 4.8% and 5.5% in the formal and informal areas respectively. Followed by arthritis, with 5% of formal household areas suffering from these diseases compared to 1.3 % in the informal areas, whereas 2% experiences TB/pneumonia in both the formal and informal areas respectively.

The results of the study are in line with literature reviewed in preceding chapters on household health status especially in communities surrounded by mining activities such as Bekkersdal. That is, mining activities do expose households to various respiratory diseases (tuberculosis/pneumonia, asthma) as a result of pollution and dust by

underground mining activities. The is high prevalence rates of HIV/AIDS associated with migratory labour effects, prostitution and substance abuse. Thus, households in Bekkersdal are exposed to various disaster related risks due to limited access to resources (including inadequate health care services), especially for those living in the informal areas, and the mining related risks further amplify their vulnerability.

**Table 27 Household Health Status**

| <b>Health Status</b> | <b>Formal</b> | <b>Informal</b> |
|----------------------|---------------|-----------------|
| TB/Pneumonia         | 2.0%          | 2.1%            |
| Malaria              | -             | -               |
| Headache/Whole Body  | -             | 1.3%            |
| Stomach Ache         | -             | -               |
| HIV/AIDS             | 4.0%          | 16.9%           |
| Diabetes             | 4.8%          | 5.5%            |
| Blood Pressure       | 23.3%         | 10.1%           |
| Arthritis            | 4.8%          | 1.3%            |
| Asthma               | 0.4%          | 0.8%            |
| Cancer               | -             | 0.4%            |
| Healthy              | 60.6%         | 61.60%          |

Source: Primary Survey Data

### **7.2.7 Household Educational Level**

Literature points out that another key indicator for vulnerability in households is education. Households with higher levels of education are less vulnerable to disaster events compared to their counterparts with less education (as discussed in chapters 2 and 3 in this thesis). This is due to the fact that, education levels provide opportunities for individuals/households to earn an income and use such income to cushion themselves against disaster events. Interestingly, most of both formal and informal household heads have high school education at about 50% each (Figure 55). This is followed by those with primary school education at 20.7% and 35.9 %, where there is a wider gap, between formal and informal households, respectively. Adult levels of education for formal Bekkersdal households stood at 4.7% compared to very low levels



of 0.7 % for the informal households. College and university levels of education were even lower in both households. In the formal areas 5.7% had university education, while in the informal households, areas only 1.7% had tertiary education. Interestingly illiteracy levels were higher in the formal areas (8.8%) compared to the informal areas (7.6%). Overall, households in the informal areas have limited education levels compared to the households in the formal areas and are therefore vulnerable to various disaster related risks in the community.

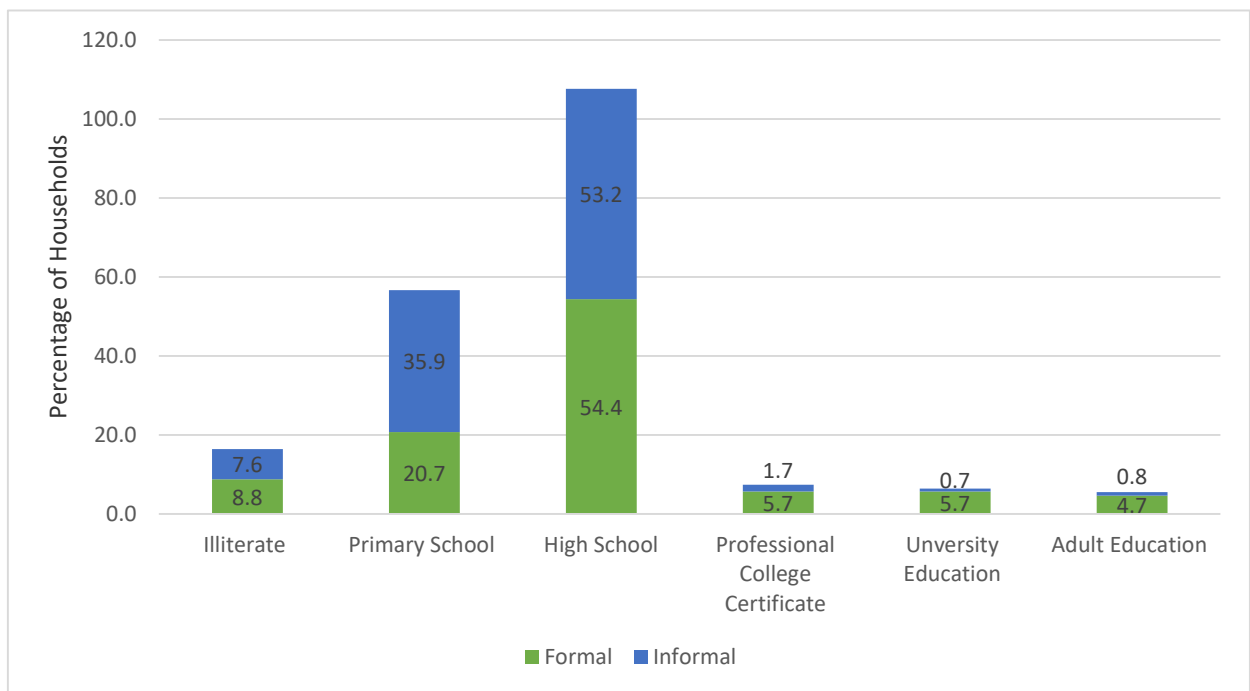


**Figure 55 Education levels**

Source: Primary Survey Data

In summary, the section above analysed the descriptive characteristics of households between the formal and informal areas of Bekkersdal in terms of demographics, age, marital status, housing structure, educational and employment levels, as well as the health status. The results of the study clearly show different vulnerability levels between the two household groups, with informal households being of a higher risk. For instance, in both groups, the majority of households interviewed were women and as such were vulnerable to disaster risks. On marital status, the majority of households are single and those married, and as such are vulnerable with higher percentages higher for informal at 65.2% and 20.9% respectively compared to the formal 42.3% and 28.5%, respectively. With regards to the employment and educational levels, the situation is

similar where households of Bekkersdal are vulnerable as they do not have employment opportunities and neither do they have highest educational attainments (university). However, the situation is more severe for the informal households at 66% and 0.7% respectively compared to the formal households at 59.8% and 5.7%, respectively. As noted above the unemployment figures from the present sample are higher than the 2011 census data. This is due to a number of factors, including that it's almost 10 years since the 2011 census and during this period, the economy has deteriorated. Many workers had been retrenched. The high unemployment rate in Bekkersdal especially for the informal households, could also be attributed to mining companies that have since the beginning of the 21st century scaled down their activities or indicated that they were working towards closure. In some instances, this major employer in the region also contributes to the high unemployment levels. Also, limited accommodation as a result of the mining-induced increase in population contributed to informal settlements being built, of poor materials and in unplanned and unsafe area (dolomitic as a result of underground mining).

### **7.3 HOUSEHOLD ASSET OWNERSHIP PROFILE: FORMAL VS. INFORMAL**

Assets play a pivotal role in the livelihood of households and in reducing vulnerability. The more assets a household has, the less vulnerable they are, and the less assets they have, the more vulnerable they become (Vatsa, 2004, Kamal, 2013, Alwang, 2001, Ta & Atoner, 2013, Becarri, 2016). So, assets such as houses, business and livestock define a household's livelihood status. In literature (and as discussed before) livelihood assets can be measured through the five capitals: financial, human, natural, physical and social capitals. A household that has limited access to (i) natural assets (land, soil and water); (ii) physical assets (livestock and equipment); (iii) financial assets (savings, salaries, remittances or pensions); (iv) human capital assets (farm labour, gender composition and dependents); and (v) social assets (information, community support, extended families and formal or informal social welfare support) is likely to be vulnerable to disasters.

### 7.3.1 Household Livelihood Status

Figure 56 shows household asset base and compares formal and informal households. Assets considered included farm, houses, livestock's and businesses. The majority of the sampled households in both formal and informal areas do not own any farm at 99.2% and 95.7%, respectively. However, the majority of households that own houses are found in the formal areas at 61.8% compared to 34.2 % in the informal areas. Likewise, with livestock, the majority of households without livestock are in the informal areas (95.6%) compared to the formal areas (85.6%). Whilst those that have livestock are at 14.4% in the informal areas compared to 4.4% in the formal areas. Surprisingly, the proportion of households with businesses in the informal areas of Bekkersdal stood at 12.8% compared to 6.5% in the formal areas, which may be indicative of the higher use of informal trading opportunities in the area. Overall, the majority of formal households (93.5 %) do not own business compared to 87.5% of informal households. In a nutshell, the results above suggest that many households are vulnerable as they have a limited asset base. These results are in line with what the literature suggests that households with less assets (as expectedly for the informal areas) become more prone to disaster related events than their counterparts who have more assets.

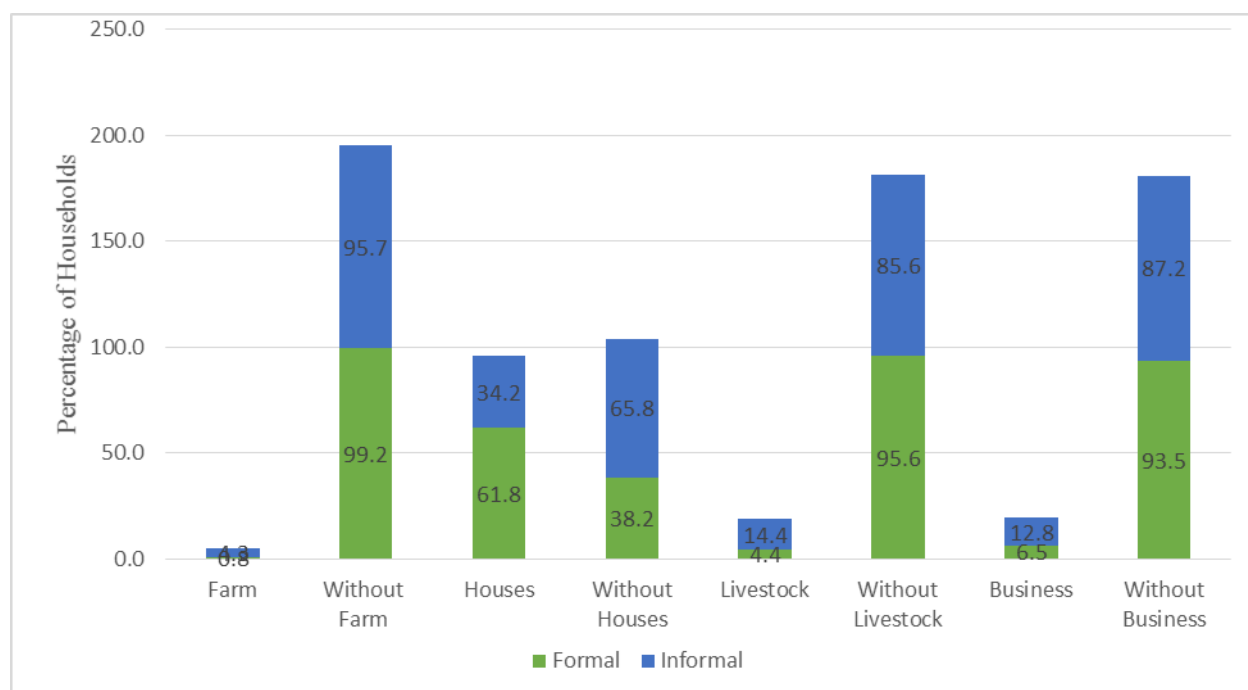


**Figure 56 Household Asset Ownership**

Source: Primary Survey Data

### 7.3.2 Household Access to Basic Services

Adequate access to basic services is another factor that mitigates vulnerability as discussed in the previous chapters of this thesis. Literature is quite clear that households with limited or no access to basic services are vulnerable to disaster risks as basic services have a bearing on how they cope with disasters or how they manage their disaster risks (Alwang *et al.*, 2001, Yodmani, 2001, Banks *et al.*, 2020). Access to basic services (water, electricity, and sanitation and refuse removal) is therefore key for households in minimising the impact of disaster risks. Table 28 shows that, although access to basic services in the formal and informal areas of Bekkersdal varies from service to service, it is lower in virtually all services for informal sector households than formal households in line with literature reviewed elsewhere in this thesis as well as the historical profile of Bekkersdal as discussed in Chapter 4. For instance, electricity, access by formal households stood at 99.6%; running water at 95.3%; sanitation 99.6%; and sewerage at 99.6%. Access to roads infrastructure stood at 99.2%. On the other hand, access by informal sector households were the worst for electricity (8.2%), followed by running water (54.7%), sanitation (56.8%), sewerage (51.5%) and roads (92.6%), compared to their counterparts. Access to telephone services and financial services averaged 90% and 80%, respectively.

Again, the results corroborate what has been argued in literature and in the historical profile discussed elsewhere in this thesis, informal settlements by virtue of their geographical location and circumstances have limited access to basic services (such as water, electricity and sanitation services) than formal households, with mining activities intensifying their status quo and vulnerability. For instance, the rapid population increase in Bekkersdal, and the unplanned and unsafe structures built in informal settlements were due to the influx of people in search of job opportunities. Further, these results corroborate the disaster practitioner results exposed in Chapter 6 of the study, where issues of lack of basic services for the informal areas was also attributed to lack of proper structures and infrastructure due to the unplanned and unsafe nature of areas, they lived in.

In turn, the rapid population increase exerted pressure towards the delivery of basic services resulting in limited services being supplied, whilst the unsuitable land where these informal settlements are built have dolomites which also form sinkholes due to the negative mining activities. As a result, services offered in the area have been limited or out of reach with households connecting illegally to electricity, and households using underground and surface water which is polluted by mining particles, whilst mining dumps and open quarries have been used as dumping areas for litter, and sewerage systems are lacking due to non-availability of infrastructure as the area is unplanned and unsafe (Van Eeden & Khaba, 2016, Van Eeden *et al.*, 2008, Matlala & Aboobaker, 2013, Lekaba, 2014).

**Table 28 Household Access to Basic Services**

|                              | <b>Formal</b> | <b>Informal</b> |
|------------------------------|---------------|-----------------|
| Electricity Supply           | 99.6          | 8.2             |
| Without Electricity Supply   | 0.4           | 91.8            |
| Running Water Supply         | 95.3          | 54.7            |
| Without Running Water        | 4.7           | 45.3            |
| Sanitation Services          | 99.6          | 56.8            |
| Without Sanitation Services  | 0.4           | 43.2            |
| Sewerage System              | 99.6          | 51.5            |
| Without Sewerage System      | 0.4           | 48.5            |
| Roads/Transportation         | 99.2          | 92.6            |
| Without Roads/Transportation | 0.8           | 7.4             |
| Telephone Services           | 96.8          | 92.6            |
| Without Telephone Services   | 3.2           | 7.4             |

|                                     |      |      |
|-------------------------------------|------|------|
| Financial Services                  | 97.2 | 77.7 |
| Without Financial Services          | 2.8  | 22.3 |
| Goods and Services Produced         | 95.6 | 83.9 |
| Without Goods and Services Produced | 4.4  | 16.1 |

Source: Primary Survey Data

### 7.3.3 Household Social Protection Mechanisms

Social capital is another alternative that households can use to cope and recover from disaster impacts. Social capital refers to a number of things that households rely upon for their upkeep and development. Social capital includes all forms of income allowances such as social grants, insurance as well as social networks (family, colleagues, burial societies, community savings or investment groups). A strong social network increases opportunities and capacity for a household to cope and adapt to disaster risks (Shah *et al.*, 2017, Alwang *et al.*, 2001, Williams *et al.*, 2018). Households with limited social capital are exposed to and are unlikely to withstand the impact of disaster events when compared to households with plenty of social capital. Households in both the formal and informal areas of Bekkersdal were probed on the social protection mechanisms at their disposal towards ameliorating the impacts of disaster risks.

Figure 57 indicates that while both formal and informal households do not have household insurance, only 15% of informal sector households have access to some insurance scheme of one sort or another. In the formal areas, 44% of household have access to some insurance scheme. This indicates that these households from both household settings especially for the informal side, are vulnerable to disaster risks and have to rely on other means to cope and recover from disaster impacts.



**Figure 57 Households Social Networks**

Source: Primary Survey Data

In terms of income allowance and social grants, close to 50% of households in the informal areas do not have access to these forms of protection mechanisms in comparison to 28% in the formal areas. Likewise, food handouts and food security programmes in the area are limited. In the informal areas, 68% of households are without access to food security programmes, compared to 46% the formal households. This indicates that households in this area have to depend on other means for their survival. Literature discussed elsewhere in this thesis also emphasises the fact that skills acquisition is a fundamental mechanism for improving one's quality of life and thus reducing vulnerability levels. A higher skills base implies low vulnerability, while the converse is true. Interestingly, skills acquisition, for both the informal and formal areas of Bekkersdal is very low, with 79% and 67% of household heads registering no formal skills, respectively.

Overall, the section above analysed the household livelihood assets between the formal and informal households. The results suggest that both households have low levels of social cohesion in terms of social networks/clubs. Only 54% and 51% participated in social networks, limited insurance cover and or receive social grants in the informal and informal households, respectively, and as such there is no coordination and cooperation by the community in assisting when disaster events take place, contributing to the vulnerability levels of households. Access to basic services such as electricity indicated that 92% of households in the informal areas do not have access and as such become vulnerable to disasters like fires compared to their counterparts who had access to electricity at 99.6%. Households that do not have access to sewerage and water supply in the informal areas were at 49% and 45%, respectively, compared to access in the formal areas at over 90%, respectively. This indicates that households residing in informal areas are more vulnerable than their counterparts and have less resources at their disposal to minimise the risks by virtue of the areas they live in. Also, the legacy of the mining activities in Bekkersdal through the negative impacts amplified the situation. More so, for the informal areas as they were unsafe due to mining affecting delivery of basic services. In terms of livelihood status (farm, business, houses), both households do not own any farm or business at over 90% in both the formal and informal households, respectively, and as such do not have additional resources to cushion themselves so as to minimise disaster impacts. For education, the results indicate that informal households have lower educational levels compared to their counterparts by virtue of their socioeconomic circumstances with less opportunities available to them.

#### **7.4 DISASTER RISKS: FORMAL AND INFORMAL AREAS**

As noted above households' experience disaster events differently, due to among others, their different capital endowments. Households with fewer capitals are more vulnerable to disaster risks compared to households more endowed with capital assets. Differences in vulnerability mean households suffer the consequences of a disaster event differently. The risks posed by each disaster event are different depending on the assets and coping mechanisms available to the household. Equally, a community is more vulnerable to some disasters than others, depending on the asset base at their disposal and the coping mechanism of that community. The section below, identified



disaster events that the Bekkersdal community has to contend with and the mechanisms they adopt to adapt or alleviate the impacts of disaster related risks in both households (formal and informal).

#### **7.4.1 Significance of Disaster Risks in Bekkersdal**

Households were asked if they have experienced disaster risks in the area in the last three years. The disaster events ranged from droughts, fires, flooding and mining related incidents. A Likert scale was used to assess whether the disaster events in the area had been very significant, significant or not significant. The results are presented in Table 29, for both the formal and the informal households. The results indicate that mining related incidents, social unrests, and diseases have been very significant in the area. Interestingly, Table 29 below indicates that informal sector dwellers cite mining related incidents (dust and earth tremors) at (60%), followed by social unrest as result of service delivery protests (59%), fires (51%) and sinkholes (42%) as the most significant risk in the area, whilst in the formal areas respondents identified dust and earth tremors, followed by service delivery protests, fires and sinkholes at 31%, 38%, 10% and 5%, respectively. Disease outbreaks (36%), flooding (23%) and windstorms (16%) were recorded to be very significant in the informal areas compared to 41%, 6% and 7% in the formal areas, respectively. The incidence of these risks is not surprising in the area, especially when comparing between the formal and informal respondents given the history of Bekkersdal and literature reviewed in the preceding chapters (WRDM, 2011, RWC, 2017/18, Koen *et al.*, 2017, Jordaan *et al.*, 2019, Van Eeden *et al.*, 2009). As argued elsewhere in this thesis, mining activities in Bekkersdal account for various disaster related risks. For instance, service delivery protests especially in the informal areas have been rife due to lack of services delivery in the area by virtue of the area being located in an unplanned and unsafe site (dolomitic conditions and sinkholes), as well as the increased population putting pressure on basic services. Yet, lack of service delivery should become the secondary risk with negative mining impacts being a primary risk factor in Bekkersdal, as discussed in this chapter and in previous chapters. Thus, the mining tremors, and dust, windstorms are very significant in the informal areas. The literature alludes to the fact that due to population increase households

resided and worked 'ten meters from mine deposits' and as such were exposed to pollution related to the negative mining impacts (mine effluents like acid mine drainage).

On fires, disease outbreaks such as cholera, and flooding; the densely populated, unplanned buildings in the informal areas meant that structures such as shacks were susceptible to fires as the area has limited basic services such as electricity resulting in households using other various means of energy that are unsafe. Cholera outbreaks have been due to open canals and underground water boreholes used by the households to access water getting polluted with mining effluents. The same case can be argued for flooding; due to lack of storm water drainage, there is no proper infrastructure in the informal areas resulting in surface water runoff when it rains. Abandoned mining dumps and quarries also get flooded when it rains contributing to flooding in the area.

Interestingly, there were also 'other' disaster related risks that were recorded as being significant in Table 29 for both the informal and formal areas at 34% and 25% respectively. These were in the form of vandalism of buildings, heavy rainfalls/floods, theft, crime, xenophobic attacks, drugs, rape, blocked sewerage, storm, shack fires, HIV/AIDS, land pollution, izinyoka (illegal connections) and water pollution. As highlighted in this chapter and elsewhere, these can also be attributed to the legacy of mining and its related negative activities in the area. On the other hand, housing development in the area is affected by goldmining and dolomite. The mining related activities have led to environmental degradation as well pollution leading to various diseases. Further, there are also possible effects of the acid mine drainage, water decanting upstream of Bekkersdal and in the adjacent areas, including the Donaldson dam. The Donaldson dam which borders the informal area of Bekkersdal is known for its high radioactivity levels due to mining effluents such as the acid mine drainage. Yet, the dam is used for various activities and for domestic consumption and recreational purpose, posing serious risks to health and the environment as alluded to elsewhere.

**Table 29 Disaster Events in Bekkersdal**

| Disaster Events in Bekkersdal Formal           | Formal                         |                           |                               | Informal         |             |                 |
|------------------------------------------------|--------------------------------|---------------------------|-------------------------------|------------------|-------------|-----------------|
|                                                | Very <sup>26</sup> Significant | Significant <sup>27</sup> | Not <sup>28</sup> Significant | Very Significant | Significant | Not Significant |
| Droughts                                       | 6%                             | 24%                       | 71%                           | 12%              | 34%         | 54%             |
| Sinkholes                                      | 5%                             | 25%                       | 70%                           | 42%              | 28%         | 31%             |
| Windstorms                                     | 7%                             | 36%                       | 57%                           | 16%              | 41%         | 43%             |
| Earthquakes                                    | 16.3%                          | 37.0%                     | 46.0%                         | 7%               | 29%         | 64%             |
| Mining related incidents (dust, earth tremors) | 31%                            | 28%                       | 41%                           | 60%              | 22%         | 19%             |
| Flooding                                       | 6.3%                           | 26.7%                     | 67.0%                         | 23%              | 29%         | 49%             |
| Fires                                          | 10%                            | 24%                       | 66%                           | 51%              | 26%         | 23%             |
| Social Unrests (service delivery protests)     | 38%                            | 32%                       | 30%                           | 59%              | 14%         | 28%             |
| Health Outbreaks (cholera)                     | 41%                            | 28%                       | 31%                           | 36%              | 19%         | 45%             |
| Other, specify                                 | 25%                            | 25%                       | 50%                           | 34%              | 25%         | 42%             |

Source: Primary Survey Data

#### 7.4.2 Significant Disaster Related Risks in Bekkersdal: Formal and Informal Households

Households were further probed on the risks identified in Table 29 above to indicate in their own words or perspective, the most problematic disaster related risks or challenges. In the formal households (100%) indicated that electricity or the illegal connections thereof, sewerage systems that are blocked, social unrests, high levels of crime, health outbreaks, unemployment, fires and flooding are the most problematic. In

<sup>26</sup> Very significant= Impact Daily;

<sup>27</sup> Significant = Impact Weekly

<sup>28</sup> Not Significant= Impact monthly or Seldom

the informal areas (100%) of households indicated that over and above unemployment, crime, social unrests, sewerage systems, illegal connection to electricity were major challenges. There are also issues of overcrowding, substance abuse, rape, and noise, late closing of *shebeens* and taverns, mining related incidents, sinkholes, dusts, dumping sites, drugs, and shacks and shack fires (see figure 58).



**Figure 58 Three Children died of shack fires in Spook town informal settlements, Bekkersdal**

Source: (EWN, 2018)

The disaster related risks and challenges mentioned by the households are in line with what the literature review highlighted, where disease outbreaks have been associated with waterborne diseases in the area, and where legacy of mining activities have negatively impacted environment and the wellness of the community. Households seem to be oblivious that mining activities in the area have also led to the lack of development and service delivery in the area due to dolomitic land and economic development, which in turn, has spill over effects that result in the social ills of high crime levels, substance abuse, diseases, unemployment and poverty.

### **7.4.3 Management of Disaster Related Risks in Bekkersdal**

Households were further probed to come up with solutions/ ideas on how the risks they have identified as problematic should be managed or resolved. Both households(informal and formal) indicated/ provided measures that should be used in managing the disaster related risks mentioned above through municipality or government intervention by way of provision basic services ( water, electricity and infrastructure) to households, proper management of the municipality by supplying services to households that pay for them, collaboration between the municipality and the community addressing challenges faced by households, effective policing and action on crime, households being educated on how to behave and deal with disaster risks and health issues, and provision of contacts or information on where to go when disaster strikes. Identified measures included creation of job opportunities especially for the youth, closure and rehabilitation of dumping sites and sinkholes, education about hygiene and health issues, acceptance of each other and social cohesion in the community.

Again, the results are not surprising given that vulnerability of households can also be attributed to their socioeconomic and environmental circumstances as highlighted in Chapters 2 and 3 of the study. Thus informal households are at the very receiving end to the various disaster risks by virtue of the various challenges they face; overcrowding, limited services, negative mining activities such as sinkholes which have contributed to the areas not receiving all basic services due to non-suitability of land; and mining-related limited economic and development services. See below direct responses from the households. Table 30 list direct responses by households:

**Table 29 Direct Responses by Households on Management of Disaster Risks**

| Formal Households                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Informal Households                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>'Proper management of the municipality and people should pay services'</p> <p>'Police must chase this theft and put in jail'</p> <p>'People / Community should stop destroy what they have as a community, they must try to sit down with the municipality and see how to solve their issues'</p> <p>'The xenophobia issue if only people can accept one another'</p> <p>'Just hang emergency numbers in case of a disaster'</p> <p>'If the government could bring more projects for people without jobs, maybe crime will end'</p> <p>'People to be taught a healthy lifestyle by the health department'</p> <p>'Service delivery must be implemented; by stop using the illegal connection'</p> <p>'Attend training and event to learn about safety'</p> | <p>'Move them to RDP's and Job creation'</p> <p>'Municipality must let Eskom to give them and they'll pay, Deliver basic services'</p> <p>'Put soil to sinkholes because it's impossible that the road can be done'</p> <p>'Tar roads needed'</p> <p>'Police must deal with crime they must control crime'</p> <p>'Health education needed'</p> <p>'People should get involved in projects around their area to overcome the crime and joblessness in the community'</p> <p>'Clean our community so that we can have personal hygiene, building of clinics nearby the community'</p> <p>'Patrolling by police and CPF; Calling fire fighters, accept each other, jobs for youth'</p> |

## 7.5 COPING MEASURES: DISASTER RISKS

Literature states that the ability of households to mitigate and adapt to disaster impacts can be explained by the type of coping mechanisms they use. Limited financial resources hinder or delay the recovery of households from disaster impacts. Likewise, with households that borrow or sell assets, while in the short run that can alleviate the pressures, in the long term it increases their vulnerability as the resources become depleted. The impact is greater for the informal compared to the formal households by virtue of informal households having limited or low access to resources (such as

financial). The findings in Table 31 corroborate the literature reviewed in chapters 2 and 3 of the thesis as well as on sections highlighted above. Households were asked to identify their coping mechanisms in relation to type of measures they used. The results from Table 31 indicate that the majority of households, both from the formal and informal areas have very little options at their disposal to cope with the impacts of disasters.

Majority of households do not have the cash to spend to minimise the impact of a disaster, and neither do they have assets to sell and they have no capacity to borrow or move to other places. Interestingly, over 90% of households in the formal sector do not sell their assets and neither have they moved to other places, whilst over 60% do not borrow or have cash to spend. Likewise, in the informal sector, over 60% and 55% of households do not sell assets and neither have they moved to other places nor do they receive aid (68%), spend cash (52%) or borrow (57%). This clearly indicates that these households do not have the resources at their disposal to cope with disaster impacts, let alone an option to move to a better place, and as such they become vulnerable. The impact is greater for the informal households as they do not even receive aid, implying that they have to rely fully on themselves.

**Table 30 Type of Measures Used by Households**

|                                            | <b>Formal</b> |           |                   | <b>Informal</b> |           |                   |
|--------------------------------------------|---------------|-----------|-------------------|-----------------|-----------|-------------------|
| <b>Type of Measures Used by Households</b> | <b>Yes</b>    | <b>No</b> | <b>Don't Know</b> | <b>Yes</b>      | <b>No</b> | <b>Don't Know</b> |
| Spent Cash                                 | 36%           | 63%       | 0.4%              | 35%             | 52%       | 13%               |
| Sold Assets                                | 6%            | 93%       | 0.4%              | 15%             | 68%       | 18%               |
| Received Aid                               | 54%           | 46%       | 1%                | 21%             | 62%       | 17%               |
| Borrowed Money                             | 38%           | 62%       | 0.4%              | 30%             | 57%       | 12%               |
| Move to other places                       | 10%           | 90%       | 0.4%              | 32%             | 55%       | 13%               |

Source: Primary Survey Data

## **7.6 RESPONSE AND RECOVERY MEASURES (ADAPTATION)**

The formal and informal households in the Bekkersdal area were asked about the type of measures their municipality used to respond to the disaster related events in the area. Table 32 below, indicates that both the formal and informal households do not have predetermined evacuation plans in place at 42% and 55% respectively. In terms of disaster information dissemination, both households indicated that there is no information shared by the municipality when disasters strike in the area, at 41% and 48% between the formal and informal households respectively. Likewise, with the availability of emergency response plans, it was the very low in both the formal and informal households at 38% and 36%, respectively. Households in both the formal and informal areas revealed that lack of community disaster risk practitioners in the area was a major challenge at 38% and 48% respectively, as indicated by absence of educational awareness on disaster risks and their impact. Predetermined evacuation plans were not done or available at 42% and 55% for formal and informal households. Reasons for non-availability to the informal households could include that the area is comprised of unplanned structures with limited infrastructure in place due to the nature of the area.

Further, households in both areas indicated the non-availability of the early warning systems in the areas as a big challenge at 47% and 54% in formal and informal areas, respectively. Limited risk assessment was reported as another challenge with over 40% of the area having had no risk assessment done in both households. Interestingly, on the provision of relief measures; the informal households reported that there was provision of shelter 47%, provision of food and medical attention at over 40% when disaster strikes; compared to 7% in the formal areas on provision of shelter, food 2% and provision of medication at 6% respectively. On rehabilitation of assets (infrastructure and subsidisation of houses) both households scored lowest, but the formal areas were the worst at 12% and 22%, respectively, compared to the informal side which scored 35% and 29%, respectively. What is emerging from these results is that; limited response and recovery measures in Bekkersdal area for both the formal and informal households. Further the results on rehabilitation of assets/ infrastructure corroborate the findings from the disaster practitioner questionnaire, where it was



indicated that these measures are limited to non-existent in Bekkersdal because for the municipality to perform the function it requires permission from the provincial level, and the process takes long. Risk assessments are only conducted once a disaster has taken place, according to the disaster practitioner.

**Table 31 Response and Recovery Measures: Formal and informal households**

| <b>Response and Recovery Measures</b>             | <b>Formal</b> |           |                   | <b>Informal</b> |           |                   |
|---------------------------------------------------|---------------|-----------|-------------------|-----------------|-----------|-------------------|
|                                                   | <b>Yes</b>    | <b>No</b> | <b>Don't Know</b> | <b>Yes</b>      | <b>No</b> | <b>Don't Know</b> |
| Predetermined evacuation plans                    | 7%            | 42%       | 52%               | 18%             | 55%       | 28%               |
| Disaster Information dissemination                | 20%           | 41%       | 39%               | 29%             | 48%       | 23%               |
| Emergency response plans                          | 38%           | 34%       | 28%               | 36%             | 48%       | 16%               |
| Early Warning Systems in place                    | 26%           | 47%       | 27%               | 25%             | 54%       | 21%               |
| Community Disaster Risk Practitioners             | 29%           | 38%       | 33%               | 36%             | 44%       | 21%               |
| Risk Assessment                                   | 31%           | 41%       | 28%               | 30%             | 47%       | 23%               |
| Creation and Provision of Shelters                | 7%            | 2%        | 91%               | 47%             | 35%       | 18%               |
| Creation and Provision of Food                    | 2%            | 3%        | 96%               | 48%             | 37%       | 16%               |
| Creation and Provision of Medical Attention       | 6%            | 3%        | 91%               | 51%             | 34%       | 15%               |
| Rehabilitation of Assets: Infrastructure Services | 12%           | 2%        | 87%               | 35%             | 42%       | 23%               |
| Rehabilitation of Assets: Subsidisation of Houses | 22%           | 5%        | 73%               | 29%             | 49%       | 22%               |

Source: Primary Survey Data

## 7.7 HOUSEHOLD VULNERABILITY LEVELS: GROUPS

Households experience vulnerability differently. What has often been missing in literature is how people perceive their vulnerability and how such perceptions compare with reality or what is obtained from quantitative analysis. In assessing household vulnerability, the starting point was to understand how individuals, both in the formal and informal sector, perceive their vulnerability to disaster events. Households were asked to rate their vulnerability using a Likert scale. As shown in Table 33, children, women, the elderly and people with disabilities, as well as immigrants, perceived themselves as being very vulnerable, both in the formal and informal sectors. In line with literature reviewed in earlier chapters, it is in the informal areas where the scores were the highest; immigrants 89%, followed by people with disabilities 87%, children and the elderly 86%, and women at 85%. In the formal areas children were highly vulnerable 62%, followed by women 57%, immigrants at 56% and the elderly at 51%, respectively. Thus, the need to reprioritise these households when targeting vulnerability groups.

**Table 32 Household Vulnerability Levels: Formal and Informal households**

| Household<br>Groups - Formal | Informal           |                      |                   | formal |        |     |
|------------------------------|--------------------|----------------------|-------------------|--------|--------|-----|
|                              | High <sup>29</sup> | Medium <sup>30</sup> | Low <sup>31</sup> | High   | Medium | Low |
| Children (0-18years)         | 86%                | 6%                   | 8%                | 62%    | 22%    | 16% |
| Women                        | 85%                | 7%                   | 8%                | 57%    | 30%    | 13% |
| Men                          | 6%                 | 83%                  | 11%               | 17%    | 59%    | 28% |
| Elderly people               | 86%                | 6%                   | 8%                | 51%    | 30%    | 19% |
| People with disabilities     | 87%                | 6%                   | 8%                | 48%    | 26%    | 25% |
| Immigrants                   | 89%                | 3%                   | 8%                | 56%    | 20%    | 24% |

Source: Primary Survey Data

<sup>29</sup> High vulnerability= households who are in critical state and would need expert assistance to recover from the impacts of the shocks.

<sup>30</sup> Medium vulnerability = households that require some level of external assistance to overcome the given shock.

<sup>31</sup> Low vulnerability= households that can adjust to given shock without needing significant external support.

In summary, the results above indicate the different vulnerability levels experienced by both the formal and informal households of Bekkersdal. Clearly, indicating that households who reside in informal areas are, by virtue of the structure/ location and density, prone to disaster related impacts compared to their counterparts, and the negative mining related impacts (dolomites and sinkholes) exacerbate their vulnerability to any form of disaster risks.

In terms of the significance of disaster risks in Bekkersdal, disaster related risks such as social unrests and mining related incidents (dust and earth tremors), windstorms were regarded as very significant in the informal areas compared to the formal areas. This can be attributed to households residing and working close to mining areas resulting to exposure to mine effluents which are hazardous to their wellbeing and environment. Also, health related illnesses such as cholera diseases were more rife in the informal areas compared to the formal areas as households in the area lack access to basic services and use contaminated ground and surface water for domestic and other uses. Fires have been caused by the high population density in the area resulting in households using unsafe methods for cooking and lighting. The 'other' disaster related risks such as substance abuse and HIV/AIDS can be attributed to social ills arising from impacts of mining and its legacy. Further, on the risks identified, both households (formal and informal), at 100%, indicated that the most problematic disaster related challenges the illegal connection to electricity, sewerage systems that are blocked, social unrests, high levels of crime, disease outbreaks, unemployment, fires and flooding. Over and above those, the informal areas also mentioned overcrowding, substance abuse, rape, noise, mining related incidents, sinkholes, dusts, dumping sites, drugs, and shacks - an indication of the dire situation in Bekkersdal, which in turn is the cause for widespread vulnerability. In terms of management of these risks, it became clear that addressing service delivery issues is the main issue. The Bekkersdal community is in a dire situation and households are vulnerable as a result of mining development which has left unsuitable land for development. Yet, households seem to overlook that given that choosing to focus on the fact that mining also offers them hope for job opportunities and a ticket out to their daily struggles of lack of resources.

On response measures, the situation did not improve for both households. The findings indicated less measures in place for response mechanism in the respective households. For instance, in the formal and informal areas there was no availability of early warning systems at 47% and 54% respectively, due to the nature of informal household structures that are built in unsafe and unplanned areas. On rehabilitation of assets the scores were lowest at 12% and 22% for both households respectively, as a result of the non-availability of this function at the local level, except by permission from the provincial government level which takes time to be effected.

For coping measures, households have limited resources at their disposal and as such are vulnerable to disaster related impacts, with informal households left with nowhere to go except rebuilding their structures as they do not have finances at their disposal to cushion themselves. For instance, majority of households do not have cash, at 63% and 52%, for formal and informal households, respectively. Neither do households move to other places when disaster events occur, at 90% for formal and 55% for informal households. For household vulnerability groups, it became obvious as per the literature that informal household groups such as immigrants, people with disabilities, women, and children were the most vulnerable groups that should be reprioritise for targeting when faced with disaster related impacts.

## **7.8 QUALITATIVE FINDINGS OF THE RESEARCH: FORMAL AND INFORMAL HOUSEHOLDS**

Qualitative analysis was also conducted on the survey data for the informal and informal households of Bekkersdal. Among others, the research probed whether the households have experienced any water related diseases in the area, whether there are social structures in place that can assist with regards to disaster related risks, the disaster risks experienced by the households in the area, the identification of the most challenging/problematic risks, as well as the measures that should be in place so as to address the risks including emerging themes. Lastly, the fieldworker observations/notes and challenges experienced during the survey were considered. Below are the findings of the qualitative analysis of the study.

### 7.8.1 Waterborne Related Diseases

Households, both the formal and the informal households, were asked to indicate if they have been affected by any water diseases in the area in the form of cholera, skin diseases and bilharzia. The results of the study corroborated the literature and historical profile reviewed in the preceding chapters. That is, Bekkersdal households indicated that waterborne diseases are rife in the area due to water pollution as residents live close to the Donaldson dam known for radioactive levels that are dangerous to the environment, humans and livelihood (see Figure 59 and 60 below). Table 34 below gives the summarised findings of the study as relates to waterborne diseases as well as direct responses from the households (formal and informal).

**Table 33 Direct Responses by Households on Waterborne Related Diseases**

#### **Direct Quotes from Informal Households**

'Yes diarrhoea, coughing and skin rash due to the sewage system that is always broken'

'Yes cholera diarrhoea because of the savage system that is floating and dumping sites that are near our houses'

'Yes skin diseases of the body and developing some irritating rash in the body'

'Yes, itching skin rash due to dirty water, bad sewerage, diarrhoea'

#### **Direct quotes from the informal households:**

'Yes, itching skin rash due to dirty water, bad sewerage, diarrhoea'.

'Yes, in fact Bekkersdal is surrounded by sewerage and the cause of disease we get is coming from the sewerage or water pollution'.

'Yes, because there is a running sewerage near our shacks. Children use to play there and affected by skin rash and scabies'.

'Children has skin diseases and cholera, because they swim in the Donaldson dam'.



**Figure 59 Woman from Bekkersdal Informal Settlement wades through the Donaldson Dam while washing clothes**

Source: Harvard Law School (2010)

The situation is worse for the informal areas as they have limited access to basic services (such as water) and as such they use the contaminated underground water for drinking as well as other household and farming activities (see Figure 59). Lack of drainage systems/ infrastructure means that dirty and unsafe water runs through the streets of Bekkersdal affecting livelihoods, with serious health impacts for the households and the environment.



**Figure 60 Cattle Drink Contaminated Water from the Donaldson**

Source: Harvard Law School (2010)

### **7.8.2 Social Structures in Place for Disaster Related Events**

In this instance, households both in the formal and informal areas were asked about whether there are any social structures in place in Bekkersdal that addressed disaster related risks. As alluded to in Chapter 6 of the study, and elsewhere in this thesis, social structures play a vital role not only in raising awareness but also in directing communities as to where and how to access relevant information. Thus, households were probed to identify social structures in place to address disaster related risks in the area and whether these structures serve their purpose. The results in table below, clearly indicate the lack of these structures in both household types, with the informal households (57%) being affected greatly by the lack of these structures. Households, both in the formal and informal areas, indicated clinics, schools, churches and police stations as their structures yet this should not be the case as per the literature. Also, another key reason for the lack of structures are the violent protests that have taken place in Bekkersdal (see Figure 61). Below are the findings for the respective households.

**Table 34 Direct Responses by Households on Bekkersdal Social Structures**

**Direct Quotes from Formal Households:**

'Only the police station and they are serving their purpose. Other structures were destroyed by the community during the service delivery protests'

'Because of the protesters we only have structure which is the police station and they are doing their best'

**Direct Quotes from Informal Households:**

'Only the police station and they are serving their purpose. Other structures were destroyed by the community during the service delivery protests'

'No place for disaster we destroy everything in Bekkersdal'

'Not in Bekkersdal you have to go to Randfontein since protesters burn their offices'

'Not anymore the hall was destroyed during protesting time and social welfare offices'

'Haven't seen such thing'



**Figure 61 Bekkersdal Protest**

Source: EWN (2013)

### **7.8.3 Disaster Preparedness and Prevention Measures (Mitigation)**

Literature highlights that mitigation measures are some of the critical measures that need to be adopted when addressing issues related to disaster risks as they prevent or



reduce the impacts related to disaster risk. These measures include awareness/preparedness and early warnings systems that need to be in place so as to assist in reduction of negative impacts caused by the disaster risks. In the Bekkersdal, households were asked to identify the type of measures they used to mitigate disaster risk related events in their area/ household. (74%) of households in the formal areas of Bekkersdal indicated that there are mitigation measures in place such as (fire extinguishers, whistle blowing and hosepipe). Whilst in the informal households, 76% identified mitigation measures in place as whistle blowing, fire extinguishers, moving from one place another, borrowing money from *mashonisa* (loan sharks), turning off candles, and seeking assistance from the police station or authorities. It is important to recognise that the measures indicated by households are not mitigation measures, but instead a combination of response and coping measures. At the same time households continue to use dangerous methods of lighting and cooking at their disposal. These are clear indications that households do not know what the mitigation measures are or should be; which can be attributed to lack of knowledge/ limited information at their disposal. Thus households in this area are in need of educational awareness campaigns on mitigation measures, which will assist in addressing or reducing the impact of disasters (see Table 36).

**Table 35 Direct quotes on mitigation measures used by households: Formal and Informal**

| Formal Households                                                                                                                                                                                                                                                                                                                                                                                   | Informal Households                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>'They have whistle to blow if there are thieves and also they make sure the hosepipe is near in case of fire;</p> <p>They only depend on calling for help if there is disaster;</p> <p>By having enough water pipes and taps in the yard in case of fire, to have burglar proof windows and doors;</p> <p>Stop illegal connections</p> <p>Install illegal connections and fire extinguishers</p> | <p>'To have a fire extinguisher in the house; delivery of basic services'</p> <p>'We use soil water to decrease fire'</p> <p>'Borrowed money form the bank or move from that place to another'</p> <p>'By educating each household about the risks and dangers of this situation'</p> <p>'Emergency numbers (10111), whistle blowing'</p> <p>'I prepare water and if I use candles I will make sure that I turn off the candles at night and put</p> |

|                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                              |
|------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Depend on emergency numbers<br>'Do not have anything prepared for disaster risk, just know that if anything may happen will go to the police'. | far from the children'<br>'Fire extinguisher, fire balls'<br>'Risk assessment, emergency response plans'<br>'Call the police for prevention, Have emergency contact number'<br>'Must have a full bucket of water in the house every time; volunteers/patrollers'<br>'To learn more about disaster risks Have emergency numbers'<br>'Cook outside to prevent the fire from burning the shack' |
|------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

## 7.9 FIELDWORKER OBSERVATIONS

This section briefly presents the views, observations and challenges experienced by field workers when administering the questionnaire to households in the formal and informal areas. See Table 37 below. What emanate from the fieldworker's observations from the fieldworker's observations are that both the formal and informal households of Bekkersdal are faced with urban township day to day challenges and social ills. More so, for the informal households with lack of access to basic services and housing, whilst residing in dolomitic areas prone to sink holes and disastrous, with Mohammed (2020), describing households who reside in informal area of Bekkersdal as the 'forgotten and hungry' ( as per figure 62 below). Table 37 below, are the direct quotes;

**Table 36 Direct Quotes: Field Workers Observations**

|                                                                                                                                                                                                                                                                                                                    |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>Formal Households</b></p> <p><b>Direct quotes:</b></p> <p>'Parent staying with her children and they survive with pension grant'</p> <p>'Don't care about what government says they say our government is full of empty promises even now their streets are dirty with not basic services, but we votes'</p> |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

'Household is struggling financially, there is no hope in their life'

'Nepotism is playing a big role in unemployment in Bekkersdal;

'Youth unemployment, a drugs and alcohol

'Sewerage system not working with sewer running on the streets'

'Elderly people living all alone without any help from relatives or community'

'This place is surrounded by sewerage and dumping sites with children playing by those areas'

#### **Direct Quotes from the Informal households:**

'There is not have water system toilet (flushed), with sewerage running in yard'

The head of the house was very angry because of the question of page 7 (Access to sewerage system)

'We struggling, need money, jobs, delivery of basic services, food and health environment'

'We need training on the situations and educating each household about the risk and dangers'

'Empty promise by the government and I am not voting again'

'Gangsterism, Drug and substance abuse'

'Crime is very high here and police need to do more'

'We are sick in the informal settlement because of dirty environment, the shacks are surrounded by dumping sites and we don't get enough oxygen'

'Unemployment has made a number of people to suffer and think of doing crime'

'No electricity, I use illegal connection'

'We are living in shack for a long time no jobs no skills that is why there is a lot of crime and

drugs abuse and early pregnancy here'

'Over-crowding can cause lot of disaster dealing with health issues in the surroundings because lot of people are getting sick all the time so they need more information and health education'



**Figure 62 The forgotten and hungry of our Informal Settlement**

Source: Mohamed, S. (2020)

In summary, the qualitative analysis of the findings from informal and formal households indicated that waterborne diseases (such as skin rash, diarrhoea and cholera) are frequent in the area. With the informal households affected the most, due to the nature of the area, which borders the Donaldson Dam which is known for mine effluents that are dangerous to the environment and livelihoods. This is further exacerbated by limited availability of water and use of ground and surface water contaminated by the mine effluents. There are no to limited availability of sewerage systems resulting in dirty sewerage on the streets and yards of informal households. This leads to water pollution and sicknesses in households. Social structures are non-existent in both households due to service delivery protests which have destroyed various structures. As such households do not know where to go in times of disaster and they end up finding temporary shelter in clinics, schools and police stations.

The situation is worse for households who reside in shacks (informal households) as the structures are vulnerable to all sorts of disasters, including fires which occur frequently as a result of dangerous forms of cooking and lighting used such as paraffin and candles. Overcrowding plays a major role in the destruction of their property, accentuating their vulnerability. In terms of the mitigation measures, none of the households used or knew what those were. Instead, households (both formal at 74% and informal at 76%) use some form coping measures (spend cash, call for help from disaster emergency numbers, or use fire extinguisher) in addressing or alleviating their vulnerability due disaster related risks. Observation by fieldworkers of the status quo of the formal and informal households during the administering of the questionnaire revealed similar results for both types of households: households are desperate for better life, lacking basic services, experience high levels of unemployment, poverty as well as social ills (crime, substance abuse and drugs, overcrowding, shacks), whilst there are also issues of mining related incidents (dust and sinkholes and acid mine drainage) that can be attributed to negative mining activities.

## **7.10 COMPARATIVE ANALYSIS OF FORMAL AND INFORMAL HOUSEHOLD VULNERABILITY: HVI**

Figure 63 shows and compares distribution of vulnerability between the households in the informal and formal areas of Bekkersdal. As such, the figure below confirms what has been discussed elsewhere in this chapter and the previous chapters that, households in the informal settlements were more vulnerable when compared to households in the formal settlements at 0.51 and 0.48 respectively. Various reasons could possibly explain why informal settlement households are more vulnerable relative to their formal settlement counterparts. The differences in the levels of vulnerability can be traced to among others, the relative asset base of the households in the two settlement categories. As noted in the previous section, households in the informal sector have limited capitals (physical, financial, natural, social or human) to withstand disaster events relative to the formal settlement area. Other factors that could possibly contribute to informal settlement dwellers being vulnerable include high levels of unemployment, poverty, the poor levels of education, as well as the location of the area and its socioeconomic and the environmental context.

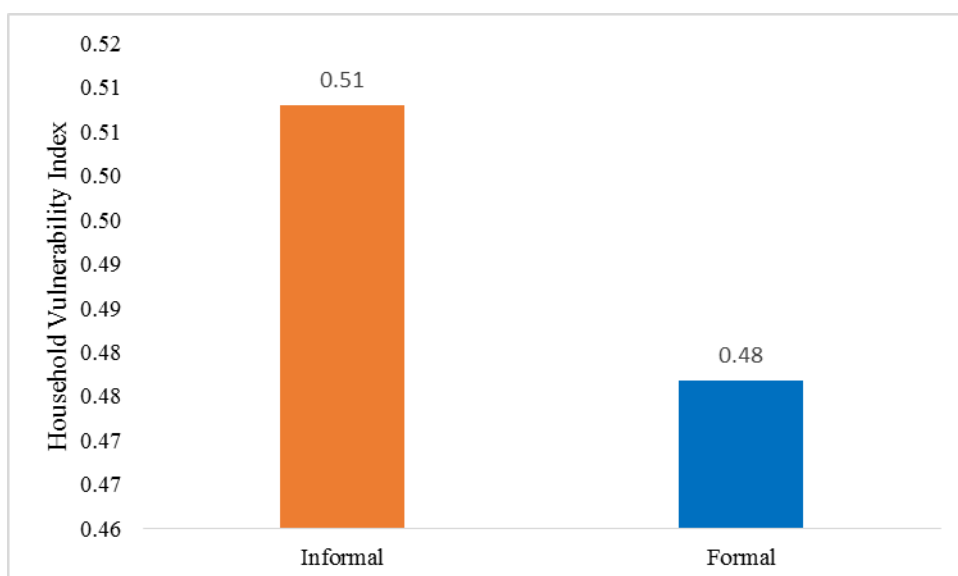


**Figure 63 Distribution of Households Vulnerability Status**

Source: Primary Survey Data

Figure 64 also confirms the above results that informal settlement dwellers are more vulnerable to disasters compared to formal settlement dwellers. The proportion of the informal household settlement dwellers that is in the moderate to highly vulnerable category is more than double (61%) that of households in the formal settlement (at 30%). In contrast, almost 70% of households in the formal settlements are in the lowly vulnerable category, compared to 39% of informal sector households in this vulnerability cohort.

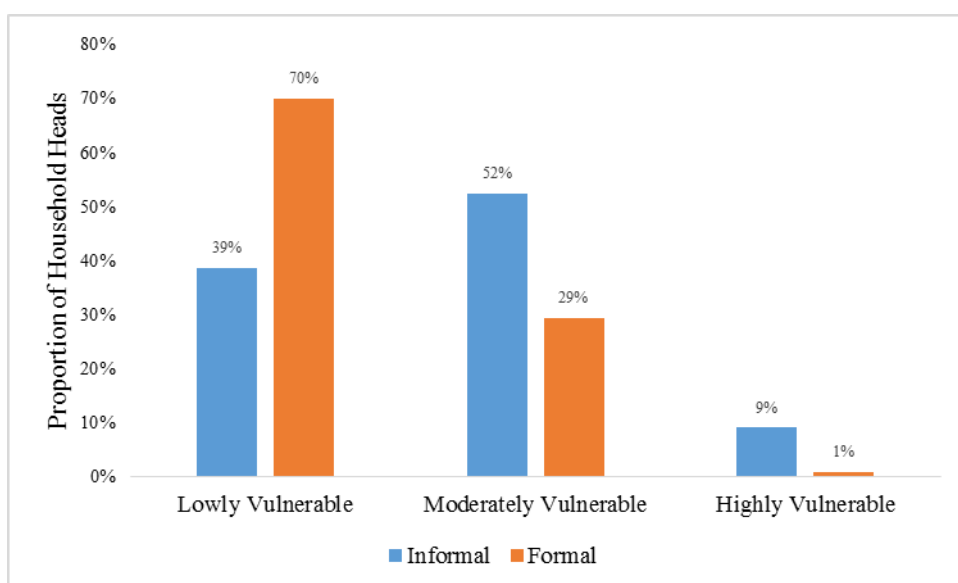


**Figure 64 Vulnerability Levels: Households**

Source: Primary Survey Data

Further, the subsections below present the HVI findings disaggregated by gender, education, marital and employment statuses, between the formal and informal households respectively.

### 7.10.1 Household Vulnerability by Gender: Formal and Informal Households

Household vulnerability of informal and formal settlement dwellers was also analysed by gender, education, marital status and employment. The results for gender, education, marital status and employment largely confirmed our expectations. For instance, Figure 65 attests to the point that females in both formal and informal sectors are more vulnerable than their male counterparts. However, more significant is the fact that female household heads in the informal sector are more vulnerable (0.52) compared to the female counterparts in the formal sector (0.49), which can also be attributed to the geographic conditions of women; that those surrounded by negative mining activities are rendered more vulnerable.

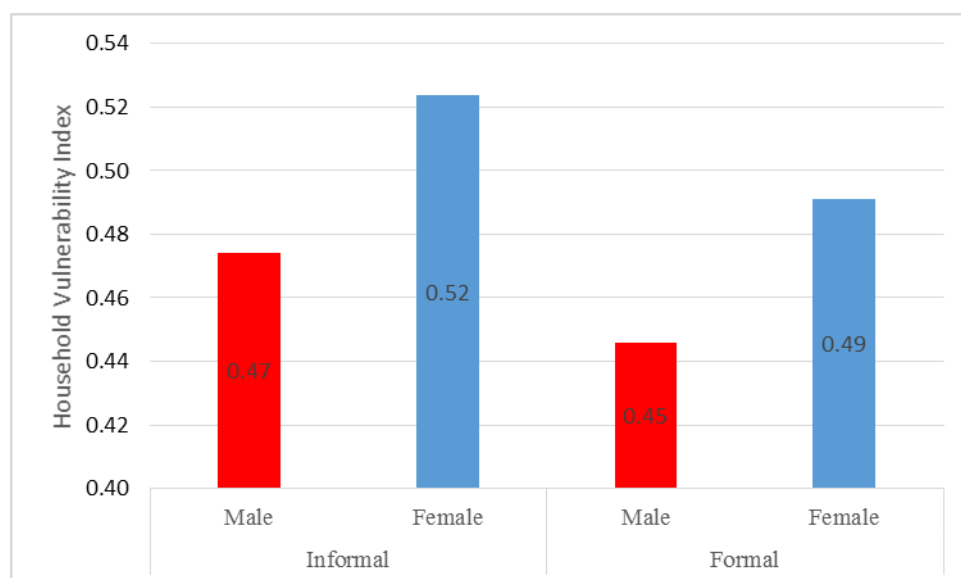


**Figure 65 Households Gender Levels**

Source: Primary Survey Data

### 7.10.2 Households Vulnerability by Education: Formal and Informal Households

In terms of educational levels, the results were as expected (education and vulnerability negative inverse relationship). In this instance, vulnerability decreases with education levels for both formal and informal dwellers. However, vulnerability was more acute in the informal areas of Bekkersdal for all education cohorts than in the informal areas, given the limited base that the households in the informal areas have in terms of opportunities than their counterparts. For instance, university education levels stood at 0.6 for the informal dwellers in comparison to 0.54 in the formal dwellers (see Figure 66 below). Interestingly, for high school and college certificate levels, the results were the same for formal and informal households at 0.50 and 0.53 respectively. On adult basic education, the informal households scored higher at 0.62 compared to the 0.56 for the formal household. The high percentage for the informal households could be attributed to, among others, the beneficiaries to this programme being households residing in informal settlements which are poverty stricken and as such are beneficiaries of various programmes and skills interventions offered by different actors to improve their social and economic welfare. The results acknowledge the importance of investing in education as a buffer against disaster events. Education increases the likelihood of those who have acquired it to secure employment and earn an income. With an income stream, individuals cushion themselves from the negative effects of disaster events.

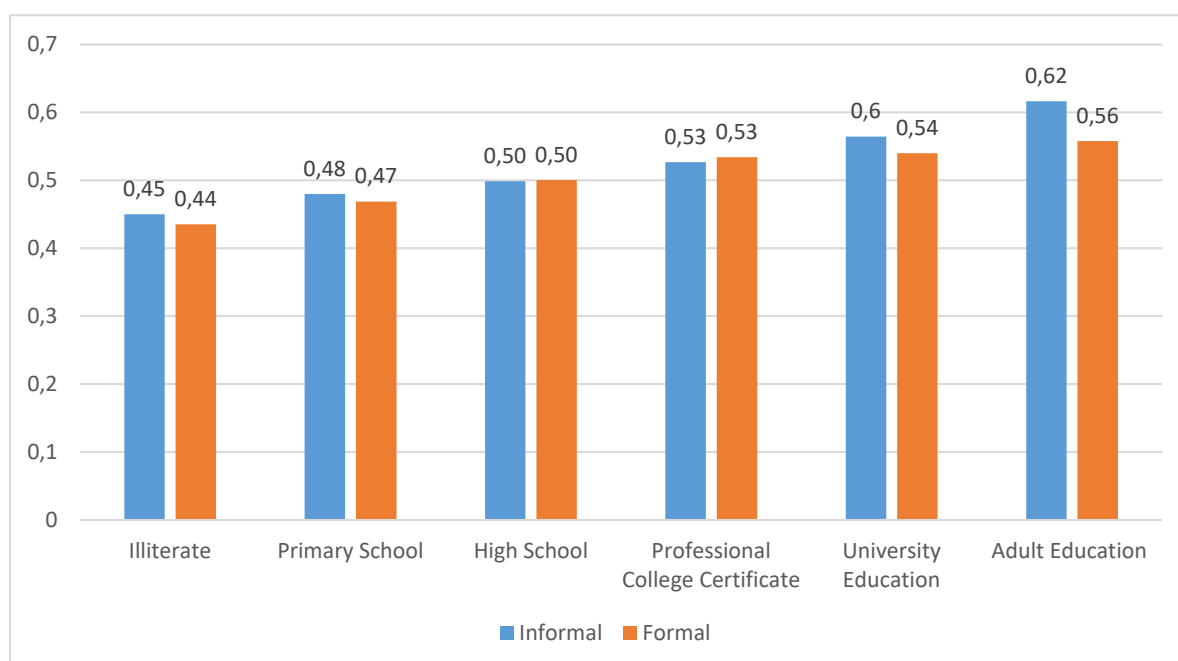


**Figure 66 Households Educational Status**

Source: Primary Survey Data



### **7.10.3 Household Vulnerability by Marital Status: Formal and Informal Households**

In terms on marital status, Figure 67 suggests that informal settlement household heads are more vulnerable on all the six marital categories than their counterparts in the formal settlements. Single, widowed, divorced all scored 0.50 in the informal settlements indicating their high vulnerability as half of the sample administered showed those results. The single, widowed and divorced averaged 0.48 in the formal households respectively. However, the figures are even higher with higher vulnerability levels for households who have separated at 0.54 in the informal areas compared to the formal areas at 0.46. In the married category, households in the formal settlements scored 0.52 compared to 0.50 in the informal settlement, which meant that households in the formal areas that are married are more vulnerable to disaster related risks than their counterparts in the informal areas. While in the co-habiting category, the reverse holds; at 0.46 for the formal households compared to 0.55 for the informal households indicating that households in the informal areas are more vulnerable. What can be deduced in this instance is the greater vulnerability of informal households to disaster related events in Bekkersdal compared to formal households – with the exception on the married category where the opposite is true.

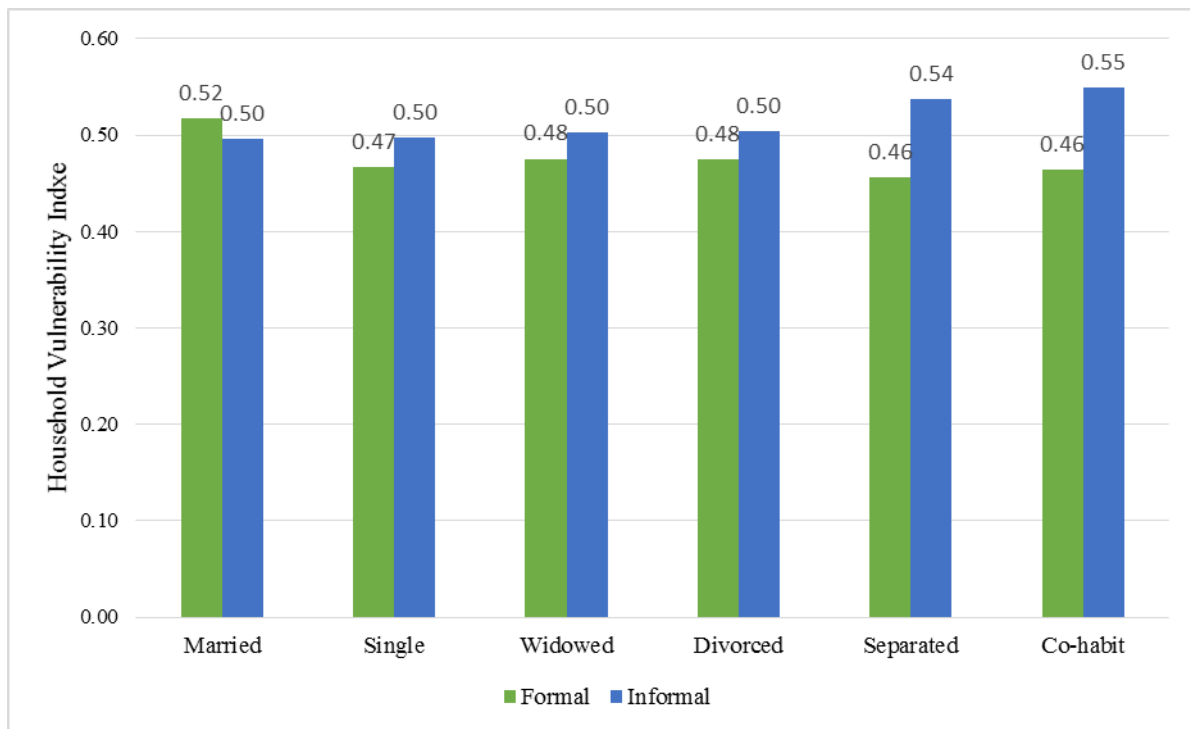


**Figure 67 Households Marital Categories**

Source: Primary Survey Data

#### 7.10.4 Household Vulnerability by Employment Levels: Formal and Informal Households

As noted in the previous chapters and elsewhere in this thesis, vulnerability is higher among unemployed and employed household heads in the informal settlements relative to those in the formal settlements. Literature suggested that as well, that the unemployed are more vulnerable than their counterparts who are employed, as they lack additional resources to minimise the impacts. What can also be argued, is that high unemployment rates are due to decline in the production of gold mining and the closure of mines, resulting in workers being retrenched and left with no choice but to reside in informal areas closer to the mines, with the hope of finding opportunities in the future. In addition, the STATS SA 2011 and the Community Survey 2017, showed high levels of unemployment among Bekkersdal households. In either category (employed or unemployed) vulnerability is greater among the informal settlements compared to the formal. That is, employment and unemployment levels scored 0.49 and 0.5 in the formal areas, compared to the formal areas at 0.47 and 0.48 for the employed and

unemployed, respectively (see Figure 6). The results suggest that income is a key determinant of vulnerability. Employed people have incomes that help them withstand the consequences of any disaster event.

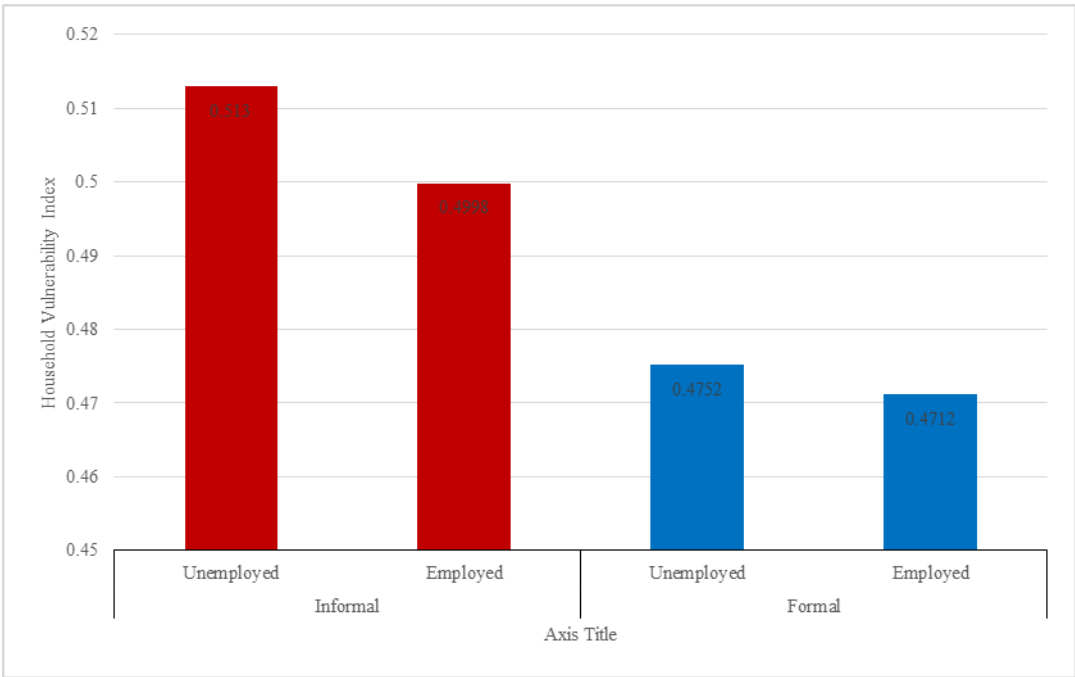


**Figure 68 Households Employment Levels**

Source: Primary Survey Data

**7.11 FACTORS INFLUENCING HOUSEHOLD HEAD VULNERABILITY:  
REGRESSION ANALYSIS RESULTS**

Another key objective of this chapter is to compare the determinants of vulnerability between formal and informal household heads. This subsection presents a comparative analysis of the determinants of vulnerability for informal and formal settlement dwellers. The regression results are presented in Table 38. The robustness tests show a well specified model. The model passes all the diagnostic tests and the coefficients carry the right and expected signs. The adjusted R2 are 97% and 82% for informal and formal households respectively.

The regression analysis provides very interesting insights on the determinants of vulnerability both in the informal and formal settlements. Generally, the explanation for

vulnerability for both informal and formal households are the same, but the levels of significance vary. Variables explained by the model include age, number of years that households reside in the area, gender, employed, marital status, income, educational levels, social club, and infrastructure and asset ownership. In terms of the analysis, surprisingly the age variable carries opposite signs for the two equations. In the informal sector model, vulnerability increases with age while in the formal sector the opposite is true. The explanation for this disparity is simple. Formal settlement dwellers are less vulnerable as they age because they have accumulated income generating assets (such as houses, land) or pensions, while informal sector dwellers have little or no assets or base to cushion them when they age.

On the years that households have resided in Bekkersdal, vulnerability decreased with more years residing in the area for both informal and formal inhabitants in Bekkersdal. The plausible reason for this result is that people with more years have developed strategies (such as social networks) to cushion themselves from disasters. That is, a 1% increase in years residing in Bekkersdal decreases vulnerability by 0.005% in the informal households while a 1% increase in years residing in Bekkersdal decreases vulnerability by 0.03% in the formal households residing in Bekkersdal.

In terms of gender, results indicate that it is a significant determinant of vulnerability in the formal sector, but not a significant factor for informal settlement dwellers. This result means that in the informal sector one's gender is not important in explaining how vulnerable they are compared to their counterparts in the formal areas. Another significant variable in explaining vulnerability is one's labour market status. Household heads that are employed are less vulnerable relative to their unemployed counterparts. In this instance, for both the formal and informal settlements, the variable is significant. For informal settlements being employed reduces a household head vulnerability by 0.1%, while for formal settlement dwellers, being employed reduces one's vulnerability by 0.4%.

Marital status comes out as not a significant determinant of vulnerability for both informal and formal settlement dwellers. On the other hand, income and education variables play a significant role in driving household vulnerability. Both income and

education assist in cushioning households against the negative effects of disasters. They both reduce household vulnerability. For example, a 1% increase in household head's income reduces vulnerability by 0.13% and 0.20% for informal and formal settlement households, respectively. Further, a 1% increase in education reduces vulnerability by 0.02 % and 0.12% for the informal and formal households respectively.

Another significant finding of this study is that social networks assist in reducing vulnerability for both informal settlements and formal settlements dwellers. In this instance, a 1% increase in social networks/clubs reduces vulnerability levels by 0.4% in the informal areas compared to the 0.3% in the formal areas. The result implies that social networks play a pivotal role in the empowerment and support of community members and have more impact in the informal settlements. Social networks assist households build a stock of capital that enables them to withstand effects of disasters.

Finally, the regression results indicate the important influence of access and ownership variables on vulnerability. Access to infrastructure for basic services (composite measure for access to water, electricity, refuse removal and sanitation) proves to be a significant driver of vulnerability in both formal and informal settlements. In both cases access to basic infrastructure reduces household vulnerability. The effect is more pronounced in the informal settlements, whereby a 1% increase in access to infrastructure reduces vulnerability by almost 0.05 %, while the same 1% increase in access reduces household vulnerability by 0.0 04% in the formal sector. Thus, to reduce vulnerability of households in the informal sector it is important that municipalities improve access to infrastructure.

Asset ownership (composite index of ownership of land, livestock and property) has also a strong influence on vulnerability. Asset ownership reduces vulnerability for both formal and informal settlement dwellers. A 10% increase in asset ownership reduces vulnerability by 0.2% in informal settlements and 0.06% for formal households. This result underscores the importance of empowering citizens with measures that will enable them to build their own assets base. Households tend to use these assets as a buffer against the negative effects of disaster events.

**Table 37 Dependant Variable: Household Vulnerability Index**

|                              | <b>Informal Settlements Households</b> |                 | <b>Formal Settlements Households</b> |                 |
|------------------------------|----------------------------------------|-----------------|--------------------------------------|-----------------|
| <b>Independent Variable</b>  | <b>HVI</b>                             |                 |                                      |                 |
| <b>Dependant Variables</b>   | <b>Coefficient</b>                     | <b>t-values</b> | <b>Coefficient</b>                   | <b>t-values</b> |
| Constant                     | -0.8332                                | -7.05           | -0.2275                              | -2.68           |
| Age                          | 0.0014                                 | 9.50            | -0.1103                              | -2.18           |
| Years residing in Bekkersdal | - 0.0048                               | -2.56           | -0.0297                              | -1.87           |
| Gender                       | 0.4523                                 | 1.24            | 0.0412                               | 2.14            |
| Employed                     | -0.0846                                | -6.36           | -0.3600                              | -2.74           |
| Marital status               | 0.0123                                 | 0.40            | 0.0026                               | 0.93            |
| Income                       | -0.1320                                | -5.16           | -0.2040                              | -2.46           |
| Educational level            | -0.0240                                | -2.86           | -0.1188                              | -3.95           |
| Social club membership       | -0.4329                                | -3.96           | -0.2946                              | 0.51            |
| Infrastructure access        | -0.0470                                | -4.79           | -0.0043                              | -3.41           |
| Asset Ownership              | -0.0203                                | -4.54           | -0.0063                              | 3.38            |
| <b>Diagnostic Tests</b>      |                                        |                 |                                      |                 |
| Number of Observations       | 738                                    |                 | 120                                  |                 |
| F(7.730)                     | 493.64                                 |                 | 354.46                               |                 |
| Pro>F                        | 0.0000                                 |                 | 0.0000                               |                 |
| Adjusted R <sup>2</sup>      | 0.8230                                 |                 | 0.9703                               |                 |
| Root MSE                     | 0.0403                                 |                 | 0.0134                               |                 |

Source: Primary Survey Data

Summing up, the household vulnerability index results clearly indicate that households in informal settlements are more vulnerable than households in formal settlements, given the socioeconomic and environmental conditions, which corroborates the descriptive analysis conducted. When evaluating the results by gender, education and marital status, households in informal settlements fare poorly when compared to their formal settlement counterparts. The regression results single out asset ownership, access to infrastructure, social networks, education, employment status, and years

residing in Bekkersdal as significant determinants of vulnerability in the informal sector. Gender and marital status do not exert any significant influence on the vulnerability of informal settlement dwellers. For formal settlement dwellers, the list of influential variables includes income, access to basic infrastructure, education, and asset ownership, while the results also suggest that social networks and marital status play no influential role on vulnerability, which is not surprising given the literature reviewed and the findings of the descriptive analysis discussed in this chapter and elsewhere.

## **7.12 CONCLUSION**

Results on the descriptive analysis of households indicated that the majority of households in the sample are female, unemployed and lowly educated. Informal households are less educated and unemployed compared to their formal counterparts. The distribution of the households by housing type indicated that the majority of Bekkersdal households reside in informal areas and thus are prone to disaster related risks than the formal areas. Thus, the majority of informal households are vulnerable by virtue of their socioeconomic and environmental circumstances. These include poverty and unemployment, substance abuse, limited basic services with low levels of education, whilst they reside in overcrowded places prone to fires, unsafe land (dolomitic) as a result of mining activities.

For marital status, both the formal and informal households of Bekkersdal are vulnerable to disaster risks due to their marital status (single, widows, female headed), even more so for the informal households due to the socioeconomic and geographic circumstances. On the employment and educational levels, the situation is similar where household of Bekkersdal are vulnerable as they do not have employment opportunities and neither do they have highest educational attainments (university). However, the situation is more severe for the informal households compared to the formal households. The high unemployment rate in Bekkersdal especially for the informal households, can also be attributed to mining companies that have since closed and production in some instance decreased resulting on job losses. In terms of health status, generally the community was reported to be healthy, whilst a few suffered from chronic illnesses. HIV/AIDS recorded highest in the informal areas compared to the

formal areas with diabetic and high blood pressure patients recorded higher in formal households compared to the informal households. These figures are alarming and corroborate the literature reviewed on various diseases that households in mining communities become exposed to due to mining. Thus, informal households are already exposed to various disaster related risks and the mining related risks further amplify their vulnerability.

In terms of household asset ownership, generally, households in formal and informal do not own any vital assets and are therefore exposed to the disaster events in the area. Access to basic services and social protection plays a pivotal role in assisting households /communities cope with the disaster impacts as well as cushioning them from disaster events. Generally, access to basic services and social protection mechanisms is higher in the formal sector than in the informal areas. On access to basic services (electricity, water, sanitation and sewerage services), informal households are without these basic services, recording highest figures compared to the formal households. This shows that informal households have limited access to these services and are vulnerable by virtue of their geographical circumstances (dolomitic land). Also, the legacy of negative mining impacts amplified the situation and vulnerability of households to lack of basic services as mining activities led to rapid rise in population, exerting pressure on the delivery of basic services. In terms of livelihood status (farm, business, houses), both household types do not own any farm or business at over 90%, and as such do not have additional resources to cushion themselves so as to minimise disaster impacts.

It is clear from these findings that both households experienced disaster related risks with limited resources at their disposal to cope with the impacts. Response measures in place are also limited. Disaster related risks such as the mining related incidents (dust, earth tremors, and windstorms) were very significant in the informal areas as compared to the formal areas by virtue of the location of these households: high density, unsafe areas with socioeconomic ills as a result of negative mining activities. Limited access to basic services, illegal connection to electricity and lack of proper sewerage systems cause flow of dirty sewerage in the streets due to limited infrastructure as a result of mining incidents such as dolomites and sinkholes. Thus the resultant service delivery



protests are regarded as the highest risk in the area, whereas negative mining activities should be at the centre stage.

In terms of the household vulnerability index, the results indicate clearly that households in the informal areas are more vulnerable than those in the formal areas. On vulnerability by gender, education and marital status, households residing in informal areas fared poorly compared to their formal counterparts. Regression results clearly indicate that gender, asset ownership, access to infrastructure, social networks, education, employment status and years residing in Bekkersdal were significant determinants of vulnerability in the informal sector. However, in the formal areas variables that are significant are income, access to basic infrastructure, education and asset ownership. Results indicate that the key disaster risks for informal households include mining related incidents, veld fires, social unrests and disease outbreaks. For formal households the list of disaster risks includes mining related incidents and social unrests. Results showed that both household types do not have resources at their disposal to cope with these disaster risks, and only a small percentage of households could afford to sell assets let alone move to other places of safety. This is a clear indication of their vulnerable status. Lastly, disaster practitioners' results and fieldworkers' observation also gave interesting results. For the former, the significant challenge in disaster response and recovery is the slow rate/delay in the rehabilitation of infrastructure in the area which needs urgent attention. In the latter, it is the dire picture of challenges faced by households residing in Bekkersdal ranging from unemployment, sickness and lack of awareness on disaster risk matters in the area that stood out.

Chapter 8, which follows, concludes the study and offers recommendations arising from key findings from the study. The recommendations relate to changes that municipalities, government, NGOs, communities and disaster practitioners need to consider and apply in addressing policy and practice for enhancing disaster risk measures.

## **CHAPTER 8**

### **CONCLUSION AND RECOMMENDATIONS**

#### **INTRODUCTION**

This chapter summaries the research undertaken. The chapter is divided into three main sections. It begins by ascertaining the research objectives of the study and assessing whether they have been met. Secondly, it summarises the conclusions drawn as presented across all the preceding chapters. Lastly, it presents recommendations based on the research study and the main findings, and as informed by gaps identified through the study which present opportunities for future research.

#### **8.2 DISCUSSION: RESEARCH OBJECTIVES**

In the main, the purpose of this study was to determine how vulnerable households in communities surrounding mining are to disaster risks. In addition, the study sought to compare the degree of vulnerability of households in the formal and informal settlements in Bekkersdal, in the Rand West City Municipality. Therefore, the primary research question of the study was aimed at identifying the underlying drivers of vulnerability to disasters in communities surrounding mining and to determine whether forms of disaster vulnerability do indeed differ in and between informal and formal households in the urban areas of Bekkersdal. To address the main purpose of the study, five objectives were formulated and discussed as summarised below.

##### **8.2.1 Objective 1:**

**To theoretically and conceptually evaluate the concepts of disasters, disaster risk and vulnerability with particular reference to disasters in environmentally brittle mining areas and focusing specifically on households in formal and informal areas.**

In order to achieve this objective, the conceptual and theoretical frameworks that underpin disasters, disaster risk, vulnerability and the household, especially as related to environmentally brittle mining risk areas and their surroundings were discussed (see Chapters 1 and 2). The literature revealed that disaster/disaster risks and vulnerability terminologies have evolved over time and that there are no universal definitions to these terms as they are discipline dependent, resulting in the terms being classified as multifaceted. However, what was conclusive was that disasters result from a loss that exceeds the capacity of the household to withstand the disaster risk impacts. Also, disaster risks occur due to hazards and exposure which makes households vulnerable to the damage or loss of lives and to the socioeconomic and environmental circumstances. Further, the literature showed that what was of essence was that, it is the pre-existing socioeconomic and environmental factors that exacerbate vulnerable situations for households.

That is, lack of/limited social cohesion and economic opportunities in the form of income and disregard or destruction of natural resources (loss of biodiversity/ livelihood due to negative mining activities) result in households being unable to cushion themselves and becoming vulnerable when disaster risk impacts strike. The situation is far worse for households residing in informal settlements than for their counterparts who reside in the formal areas due to the prevailing socioeconomic and environmental factors. Various theories on disaster/disaster risks and vulnerability were reviewed. The findings from the literature with regards to these theories showed that there are underlying drivers that result in households being vulnerable, and these require a multidisciplinary approach to address them. The literature showed that disaster and disaster risk theories have evolved from classifying disaster/disaster risk as acts of God to social constructs, paving way for multiple approaches for addressing risk or target vulnerability interventions effectively. Also, the literature reviewed in this section served as the basis for the variables that were used in the formulation of the survey questionnaire for the present study as discussed in the methodology section.

### **8.2.2 Objective 2:**

**To review current models on disasters, disaster risks and vulnerability levels in particular of households (between informal and formal) in mining areas and to establish, through qualitative fieldwork research, whether there are gaps.**

Based on the conceptual and theoretical frameworks discussed, this section reviewed empirical studies in the area of disaster and disaster risks, and on vulnerability, in particular, of households both in informal and formal areas including households residing in mining areas with the aim of determining whether there are any research gaps. What emerged from the empirical literature was that, there are a variety of models used to measure disaster, disaster risks and vulnerability, in order to be able to assess the impact and vulnerability of households to disaster risks. These range from the use of indices, case studies and survey approaches. The use of indices suggest that vulnerability is influenced by, among others; the socioeconomic, demographic and environmental circumstances surrounding households. Also, using indices can assist, in devising early warning systems. These indices further assist in identifying vulnerable groups in society. However, the downside with the use of vulnerability indices is their subjectivity which requires constant and continuous empirical scrutiny in order to ensure their robustness. The indices, case study and survey analysis approaches highlighted various dimensions that need to be taken into account when measuring household vulnerability and some of the measures were adopted in the methodology of the present study.

Case study approaches and surveys have been used to study vulnerability to disasters risks. The review of the case study approaches and surveys indicated that livelihood variables matter and should be taken into account when measuring vulnerability of households to disaster risks. The review indicated that households become exposed and vulnerable based on their geographical location. Lack of access to resources (economic, financial physical, social and environmental) was shown to exacerbate the vulnerability. With respect to mining activities' impact on communities residing in the surrounding areas, the case study approaches and surveys all pointed to the devastating negative effects of mining activities on the environment (acid mine

drainage, mine tailings and dumps, pollution which affects lives and livelihood of the households), which exacerbate the challenged socioeconomic and wellbeing conditions of the households and communities. The comparability between the formal and informal households revealed that in urban townships the effects of negative environmental impacts of mining activities are damaging to wellbeing and the environment of households residing nearby. The situation is worse for informal households, for migrants, and for households living nearby mining areas than their counterparts in formal areas due to, among others, the socioeconomic ills in informal areas. Also, some of the mining-related disasters/ disaster risks shouldn't occurred but do so as a result of irresponsible gatekeeping in governing sectors which enables non-compliance with safe mining practice regulations, safety and care measures by mining companies.

### **8.2.3 Objective 3:**

**To examine the historical evolution of disasters, disaster risks and vulnerability between informal and formal households in the Bekkersdal area.**

In order to achieve this objective, the profile of the site for case study was reviewed. The analysis reviewed the history of the area including giving an outline of the socioeconomic and environmental factors, as well as the township's disaster risk and vulnerability profiling. What emanated from the review, was that the township owes its existence to mining activities (such as gold mining) in the area, which has been the key driver of the Bekkersdal economy. The mining economic activity in the area attracted many workers from within the country and the Southern African region. As the population increased many workers could not find accommodation in the formal areas, and instead joined the ever-growing informal settlement. Such that the rapid growth of the informal sector has had its own challenges, among them poverty, unemployment and squalor became endemic especially in the informal settlements.

The rapid population increase also exerted pressure on delivery of basic services due to lack of infrastructure as the area was unsafe for building, being dolomitic land as a result of environmental degradation from mining which made the area prone to sinkhole formation. As noted in the literature and in the profiling section of this thesis, mining activities in the area had negative externalities (acid mine drainage, regarded as the

worst environmental damage), depriving the community of Bekkersdal clean water, wellbeing and livelihoods. Taken together, the foregoing profiles highlight a number of variables that account for the disaster risk and vulnerability of the Bekkersdal community. A significant population from Bekkersdal suffers from acute levels of poverty, inequality, unemployment and limited access to basic services. All these factors potentially amplify the risks and accentuate the vulnerability of the community of Bekkersdal.

#### **8.2.4 Objective 4:**

**To examine vulnerability levels and drivers of vulnerability of informal and formal households in the Bekkersdal area of RWC.**

Reiterating the two questions that underpin this study: What are the vulnerability levels of informal and formal households, (individually and comparatively?) in the Bekkersdal area of RWC? To achieve this objective, research techniques were used to answer these two key questions as found in the literature (key models) reviewed thereby informing the data collection methods. Consequently, a case study approach was used to explain household vulnerability in the Bekkersdal area as well as to enable comparison of the vulnerability levels of households, both formal and informal. A mixed method (quantitative and qualitative) approach was adopted.

In the quantitative aspects, descriptive analysis was used to determine variables that have a bearing on household vulnerability. An estimation of the vulnerability index was used which was able to capture household vulnerability in Bekkersdal for both the formal and informal residents. Estimation of the key determinants and drivers of vulnerability was achieved by regression analysis. Qualitative analysis was also conducted to construct a situational analysis of the community. Overall, the results of the study show that the community and households have all the signs of vulnerability or likelihood to be vulnerable:

- The majority of households surveyed were females, either single, widowed, divorced, separated or cohabiting, with low educational attainment levels.

- The majority of households in Bekkersdal reside in shacks in the informal areas which are unsuitable for building – dolomitic land which had a tendency to form sinkholes found in the area due to mining activities. There are also high levels of unemployment, attributed to the closure of mines occurring in the area.
- There are also various ailments; an indication that households in Bekkersdal are vulnerable to various disaster related health risks (cholera, skin rash, respiratory disease) which are linked to exposure of households to pollution as result of mine effluents in the area.
- Households in the Bekkersdal community do not have access basic services such as electricity, water, sanitation, and sewerage systems, partly due to the negative mining activities in the area which have resulted in shortages/ limited access to basic services. Thus, service delivery is a big risk or a secondary risk because of the mining and environmental activities that have and are taking place in the Bekkersdal mining community. In other words, service delivery, is a secondary risk driven by other primary risks (such as the negative mining impacts) making it difficult and impossible to supply basic services in Bekkersdal.
- To quantify the vulnerability levels of the Bekkersdal community, an asset/capitals-based household vulnerability index was computed for all household heads and the results corroborated survey findings. That is, females were found to be more vulnerable than men, and households with low education levels were the most vulnerable. Regression analysis results showed that increase in education has an inverse relationship with vulnerability. That is, the more the years of education, the lower the levels of vulnerability as education acts as an asset that cushions the household against disaster impacts. Age and marital status had a positive effect, that is, the older the household head is, the more the vulnerability and those who are married experience the effects of vulnerability less than their counterparts who are single, for instance. On infrastructure assets, results indicated that Bekkersdal households have less of these assets and were more vulnerable to the disaster risks.
- Lastly, the disaster practitioner survey and fieldworkers' observation also elicited interesting results. In the former, the significant challenge in disaster response and recovery is the slow rate/delay in the rehabilitation of infrastructure in the area which needs urgent attention. In the latter, was the dire picture of

challenges faced by households residing in Bekkersdal ranging from unemployment, sickness and lack of awareness on disaster risk matters in the area. Also, these results corroborated the household survey findings. That is, disaster related risks in Bekkersdal relate to various forms of service delivery challenges, such as inadequate sewerage treatment, inappropriate land use, crime and service delivery protests, which can be argued to be attributable to the negative mining related activities (shortage of accommodation, waste disposal challenges also due to mine dumps being turned into dumping sites by households). Sinkholes earth tremors pollution and dust were shown to be due to the negative mining activities. However, what was interesting in the results from the questionnaire by the disaster risk practitioner responsible for RWC in the WRDM was that mining and industrial development, underground mining, and wetlands destruction, were not seen as being attributable to the mining activities in Bekkersdal. Equally so droughts, sinkholes, windstorms, earthquakes, mining related incidents, flooding were indicated as not significant. It can be argued that some of the reasons for the practitioner to underplay such risks relate to the fact that they are an indictment to them.

A comparative analysis of the vulnerabilities of households in the formal and informal settings was conducted in answer to the main research question of the study. The results corroborated the general findings discussed in chapter six and highlighted above, that generally the impact was more severe to the informal households compared to the formal households with some of the findings highlighted as:

- Results on the descriptive analysis of households indicated that the majority of households in the sample are female, unemployed and lowly educated. Informal households are less educated and unemployed than their formal counterparts. The distribution of the households by housing type indicated that the majority of Bekkersdal households reside in informal areas at 74% and thus are prone to any form of disaster related risks than the formal areas (26%). Thus, the majority of households are vulnerable by virtue of the socioeconomic and environmental circumstances. These include poverty and unemployment, substance abuse, limited basic services, with low levels of education, whilst they reside in



overcrowded places prone to fires, unsafe land (dolomitic) as a result of mining activities.

- With regards to disaster risks and significance, it was clear from the findings that both household types experienced disaster related risks with limited resources at their disposal to cope with the impacts, including the limited response measures in place, with severe impact to the informal compared to the formal households. Significance of disaster related risks such as the mining related incidents (dust, earth tremors, and windstorms) were very significant in the informal areas as compared to the formal areas by virtue of the location of these households in areas with high density, that are unsafe and have several socioeconomic ills of which mining related incidents have played a major role/ contributed to the situation. Socioeconomic challenges included the limited access to basic services (illegal connection of electricity and lack of proper sewerage systems a cause to running of dirty sewerage in the streets) due to limited infrastructure as a result of mining incidents such as dolomites and sinkholes, hence the service delivery protests are regarded as the highest risk in the area, whilst negative mining activities should be at the centre stage.
- Over and above the mining incidents indicated above, social ills associated with mining activities such as, high levels of crime, disease outbreaks, unemployment, fires and flooding were identified as the most problematic by both the informal and formal households. Including the dumping sites, drugs, and shacks in the informal areas. An indication of the dire situation of Bekkersdal which in turn is the cause of severe vulnerability of households in the informal areas.
- In terms of the household vulnerability index, the results indicate clearly that households in the informal areas are more vulnerable than those in the formal areas. Even on vulnerability by gender, education, and marital status, households residing in informal areas fared poorly when compared to their formal counterparts. Regression results clearly indicate that gender asset ownership, access to infrastructure, social networks, education, employment status and years residing are significant determinants of vulnerability in the informal sector. However, in the formal areas variables that are significant are income, access to basic infrastructure, education and asset ownership. Results indicate that the key

disaster risks for informal households include mining related incidents, veld fires, social unrests and health outbreaks.

#### **8.2.5 Objective 5:**

**To make recommendations with regard to the management of disaster risks and vulnerability in the households under study, of the post-mining risk area under study.**

The findings of the study highlighted above resulted in the recommendations stated in section 8.3 below.

### **8.3 SUMMARY OF CONCLUSION AND RECOMMENDATIONS ON RESEARCH STUDY**

This section highlights key points that have emerged from the study as well as policy recommendations that municipalities, government, NGOs, communities and disaster practitioners need to consider and apply in addressing and enhancing disaster risk measures so as to alleviate the disaster risk impacts. Disaster risks found were unique to households residing in areas surrounding mining. Generally urban townships are engulfed with challenges that have become the norm; high poverty and unemployment, lack of access to basic services, limited education and income opportunities, high crime rates as well as growing informal settlements. These challenges imply that already households in these urban townships are vulnerable to disaster risks by virtue of possessing limited assets. More so, for households residing in areas surrounding mining, there are also environmental disaster risks in the form of dolomitic and sink hole conditions, mercury metals, water and air pollution land degradation, dust, dam tailings, acid mine drainage, compromised health exposure in form of respiratory illnesses.

The socioeconomic and environmental context of households play a vital in terms of vulnerability of households and when these factors are compromised, vulnerability of households becomes accentuated, as households become vulnerable due to their disadvantaged positions. Some of the lessons drawn from this study include that the importance of indigenous knowledge in risk reduction initiatives should be at the fore. In

terms of mining disasters, non-compliance with rehabilitation of mine regulations has led to various disaster risks such as mine/dam tailings. Noncompliance is generally a result of organisational failures. There is a need to understand informal settlement demographics, financial and social aspects, and location/environmental context as they are key to addressing disaster risk profile in the informal areas. At the time of the survey, disaster practitioners indicated that there is no municipal disaster risk unit/ office at the municipal level to oversee disaster risk issues in the municipality, it was only available at district office with limited officials. Response measures and rehabilitation efforts were non-existent at the RWC municipality, until a directive is received from the provincial government which takes time. Mitigation measures are limited. At municipal level there are volunteers who are not paid, not even a stipend. There is also political interference in disaster risk management, which in some instances, result in plans not being executed properly. Prevention and mitigation strategies as well as the response and recovery measures are limited. There is widespread lack of basic services especially in the informal settlements. For example, pit latrines are used as there is no drainage systems. There are no social structures in place as they were destroyed during service delivery protests. Illegal electricity connections are rife and the cause of many fires in Bekkersdal. The non-timely rehabilitation and replacement of assets (infrastructure/ houses) after a disaster has occurred is problematic. Mining activities trigger seismicity which results in damages or even collapse of infrastructure which deepens vulnerability of the households.

**Thus, the study recommends the following:**

- The need for environmental impact assessment to be conducted throughout the life cycle of the mines including interlinking mining activities so as to minimise the negative environmental impacts.
- Appropriate measures to be put in place to address and minimise negative effects of mining activities in communities; such as protection of natural resources and the rehabilitation of mine tailings as well as sustainable mining where negative impacts are minimised.
- For disaster risk reduction mechanisms to be effective they should include households own local conceptions as this will assist in terms of building trust,

among communities and those involved in making decisions/ disaster practitioners towards practical measures for disaster risk reduction.

- Policymakers/ disaster practitioners in making policies and their implementation need to take into account the socioeconomic and environmental factors as these factors play a major role in addressing vulnerability of households while improving their socioeconomic and environmental circumstances.
- Measures should be in place for addressing occupation or building in informal areas; prevention of informal or illegal construction, avoidance of construction along the banks of the river, construction of storm water collection systems as well as educational awareness, including discouraging households from residing in areas that are prone to disaster risks.
- Addressing vulnerability to disaster risks needs political commitment and good governance, risk identification and assessment of the socioeconomic and environmental impact on disaster risks. There is need to improve and manage communication for risk reduction methods and capacity building.
- In terms of mining, improvement in social welfare and environmental wellbeing of the local community should be a priority though collaborative efforts so as to achieve sustainable mining activities.
- There is a need to classify disaster risks so as ensure that appropriate mitigation and adaptation strategies are in place.
- Mining disasters can be addressed through enforcement through change in organisational structure (and application of safety rules and measures), with penalties imposed for noncompliance.
- In addressing vulnerability more so for the informal households; there must be empowerment of informal communities through provision of access to resources (physical, social, financial, and human and natural resources. Including provision of education and training, updating the census to ensure inclusivity and effectiveness, improving community participation improving land tenure security and ensuring provision of basic services.

- There is need to address issues of unemployment in the country especially youth unemployment as it tends to drive many other vices, including crime and substance abuse and in a mining area like Bekkersdal, many of the unemployed resort to illegal mining.
- There is a need for a municipal disaster risk management unit in the municipality, which would be dedicated to addressing disaster related risks in area.
- Further, government, especially at local level must be critically involved in addressing rehabilitation efforts at the municipal level as it looks beyond the return to status quo but towards long term measures that are sustainable and assist in addressing root causes of vulnerability among households.
- There is need for mitigation measures to be in place at the municipality. These measures include awareness/preparedness and early warnings systems that need to be in place to reduce negative impacts caused by disaster risks.
- In terms of mining, the municipality need to include, disaster risks caused by seismicity in their disaster risk reduction/ IDP plans.
- The environmental impact assessment of mining projects should encompass the entire life cycle of the mine, the assessment of negative impacts and societal benefits, as well as the need to reinforce procedures for protection of the environment and public health (such as technology to reduce waste/ mine tailings). Legal requirements must be enforced that prevent contamination of water, including measures put in place to monitor and address contamination of water from the source. Also, mining activities should be intertwined with sustainable development goals so as to ensure present and future generations will have resources to meet their basic needs (e.g. alternative sources of energy) so as to decrease environmental impacts.
- There is need for monitoring early warning systems and backfilling mining so as to protect ground water contamination.
- When mines close, there should be governance norms related to that, such as mining income translated into programmes that would benefit the community, for instance, in terms of employment opportunities and skills.
- There must be collection of data on disaster risks through mapping of vulnerabilities, so as to have effective strategies.

## **8.4 RESEARCH GAPS**

The study mainly focused on the Bekkersdal area in the RWC in the Far West Rand and covered both informal and formal households. It compared vulnerability levels to disaster risks in the area and coping mechanisms currently in place. This study focussed on a small mining area of Bekkersdal, thus limiting any generalisations to South Africa and the mining industry in particular. On the other hand, resource constraints did not allow for a larger, more representative sample. For future studies it is important to cover other mining areas of the country to get a sound picture of disaster risk associated with mining activities. Future studies can also look at other industries, such as agriculture and forestry.

The study also covered vulnerability to disasters, mainly associated with mining-related activities. There is a need for future studies to interrogate the vulnerability of households to other disasters such as floods, fires, drought or even climate change. The focus point of the study was not the individual, but the household (in the formal and the informal) in the Bekkersdal area. Building from this study, future studies can be more focussed and look closely at individual vulnerability.

## **8.5 CONTRIBUTION TO BODY OF KNOWLEDGE**

It is envisaged that, by using this study, disaster practitioners will be able to effectively target households that are most vulnerable to disaster risks. It is envisaged that this study will add to the body knowledge and literature through revising some old techniques that have been used in disaster risk measures through remodelling so as to cater for other critical variables that have not been included in the past studies, as one size approach does not fit all. More so, on disaster risks surrounding mining communities (such as dolomites, sink holes, earth tremors, dam tailings, acid mine drainage and pollution) as their challenges goes beyond/ over and above those labelled the norm in urban townships (such as poverty, unemployment, lack of basic services, high levels of crime, limited education and income opportunities). Further, the study will benefit all the respective role players in terms of offering policy-makers advice on development initiatives, on fast tracking the process of decision-making, improving

planning and coordination, as well as prevention, mitigation, preparedness, response and resilience to every form of disaster risk.

This study hopefully will contribute to better and more effective targeting of public resources and programmes and enhance formulation and evaluation of policies at the local level which is the first point of call by the community when disaster risks strikes.

In order to be able to address disaster related risks effectively, the coordination and the integration of all role players are prerequisites for proper management of disasters and this applies not only to the spheres of government, but to all sectors involved, namely nongovernmental organisations (NGOs), community-based organisations and the private sector as well. The complex nature of every form of disaster risk requires this extended scope regarding consultation and cooperative relationship. Every role player has a unique task to perform, since disasters need to be dealt with as a management function rather than as an emergency rescue service. A multidisciplinary approach is required with the community as the main focal point in order to better understand and measure their vulnerabilities.

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## APPENDIXES

### APPENDIX 1: HOUSEHOLD VULNERABILITY QUESTIONNAIRE

The answers to the questionnaire should be provided to the fieldworker by a knowledgeable household member/s (the member should be somebody that is most familiar with the household and Bekkersdal Community).

#### INSTRUCTIONS TO FIELDWORKER:

1. The household member that voluntary participates should answer EACH question.
2. Some questions ask you to specify the answer on the line(s) provided (i.e. open questions and you must write down the exact words of the household member).
3. The head of the research study will keep this page with your personal information separately and safe. The information will only be used when there is a need for a follow-up visit and future meetings.

| Result of visit (for recordkeeping on the completion of questionnaire at each household) |                |                |
|------------------------------------------------------------------------------------------|----------------|----------------|
|                                                                                          | Visit 1        | Visit 2        |
| Date                                                                                     | dd / mm / yyyy | dd / mm / yyyy |
| Fieldworker/s name/s                                                                     |                |                |
| Signature leading researcher/ supervisor                                                 |                |                |

## 1. Household Identification

### 1.1 Household details

|          |                                                      |  |
|----------|------------------------------------------------------|--|
| <b>a</b> | Municipality stand number                            |  |
| <b>b</b> | Name/s of household member providing the information |  |
| <b>c</b> | Ward/Area                                            |  |
| <b>d</b> | Contact number (cell/tel.)                           |  |

### 1.2 Please tick the household member's skills with languages (Good=1a; Average=1b; Poor=1c)

| Languages |                             | 1     |    |    | 2    |    |    | 3     |    |    | 4          |    |    |
|-----------|-----------------------------|-------|----|----|------|----|----|-------|----|----|------------|----|----|
|           |                             | Speak |    |    | Read |    |    | Write |    |    | Understand |    |    |
| <b>a</b>  | English                     | 1a    | 1b | 1c | 1a   | 1b | 1c | 1a    | 1b | 1c | 1a         | 1b | 1c |
| <b>b</b>  | Sotho                       | 1a    | 1b | 1c | 1a   | 1b | 1c | 1a    | 1b | 1c | 1a         | 1b | 1c |
| <b>c</b>  | Xhosa                       | 1a    | 1b | 1c | 1a   | 1b | 1c | 1a    | 1b | 1c | 1a         | 1b | 1c |
| <b>d</b>  | Zulu                        | 1a    | 1b | 1c | 1a   | 1b | 1c | 1a    | 1b | 1c | 1a         | 1b | 1c |
| <b>e</b>  | Tswana                      | 1a    | 1b | 1c | 1a   | 1b | 1c | 1a    | 1b | 1c | 1a         | 1b | 1c |
| <b>f</b>  | Other,<br>Specify           | 1a    | 1b | 1c | 1a   | 1b | 1c | 1a    | 1b | 1c | 1a         | 1b | 1c |
| <b>g</b>  | What is your home language? |       |    |    |      |    |    |       |    |    |            |    |    |

## 2. Personal Information (for every household start with the household head)<sup>32</sup>

|    | 2. Personal Information of a household | 2.1 Age: (years) and age (of your household members) | 2.2 Sex: 1=Male, 2=Female | 2.3 Number of years living in Bekkersdal | 2.4 How many members are living in your household excluding renters | 2.5 Relation to Head: 1=Head, 2= Spouse, 3=Mother, 4=Father, 5=Son 6=Daughter, 7= Niece/ Nephew, 8=Grandparent, 9=Employee, 10=Other, specify | 2.6 Marital Status: 1=Married, 2=Single, 3=Widow, 4=Divorced, 5=Separated, 6=Co-habiting, 99= n/a | 2.7 Highest Education level: 1=Illiterate, 2=Primary School (Grade R-7), 3= High School (Grade 8-12), 4=Professional College Certificate, 5=University Education, 6=Adult Education, 7=Other, specify | 2.8 Employment : 1=Unemployed, 2=Employed | 2.9 Residential Status: 1=SA citizen, 2=Immigrant, 3=Visitor/Holiday, 4= Only work in SA (not a citizen) 5=Other, specify | 2.10 Type of Household: 1=Formal, 2=Informal | 2.11 Type of Housing Structure : 1= Brick, 2= RDP, 3= Wood, 4= Mud, 5= Shack, 6= Other, specify | 2.12 Health Status : 1=TB/Pneumonia, 2=Malaria, 3=Headache/ Whole body ,4=Stomach ache, 5= HIV/AIDS, 6= Diabetes, 7=Blood Pressure ,8= Arthritis, 9=Asthma ,10=Cancer, 11=Other, specify, 12=Healthy | 2.13 Disability : 1=Blind, 2=Deaf, 3= Crippled, 4=Mentally Unfit, 6=Albinism, 7=Other specify 8=n/a | 2.14 Parenthood Status for children Less than 18yrs: 1=Both parents alive, 2=Single parent orphan (mother alive), 3=Single parent orphan (father alive) |
|----|----------------------------------------|------------------------------------------------------|---------------------------|------------------------------------------|---------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|-------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1  |                                        |                                                      |                           |                                          |                                                                     |                                                                                                                                               |                                                                                                   |                                                                                                                                                                                                       |                                           |                                                                                                                           |                                              |                                                                                                 |                                                                                                                                                                                                      |                                                                                                     |                                                                                                                                                         |
| 2  |                                        |                                                      |                           |                                          |                                                                     |                                                                                                                                               |                                                                                                   |                                                                                                                                                                                                       |                                           |                                                                                                                           |                                              |                                                                                                 |                                                                                                                                                                                                      |                                                                                                     |                                                                                                                                                         |
| 3  |                                        |                                                      |                           |                                          |                                                                     |                                                                                                                                               |                                                                                                   |                                                                                                                                                                                                       |                                           |                                                                                                                           |                                              |                                                                                                 |                                                                                                                                                                                                      |                                                                                                     |                                                                                                                                                         |
| 4  |                                        |                                                      |                           |                                          |                                                                     |                                                                                                                                               |                                                                                                   |                                                                                                                                                                                                       |                                           |                                                                                                                           |                                              |                                                                                                 |                                                                                                                                                                                                      |                                                                                                     |                                                                                                                                                         |
| 5  |                                        |                                                      |                           |                                          |                                                                     |                                                                                                                                               |                                                                                                   |                                                                                                                                                                                                       |                                           |                                                                                                                           |                                              |                                                                                                 |                                                                                                                                                                                                      |                                                                                                     |                                                                                                                                                         |
| 6  |                                        |                                                      |                           |                                          |                                                                     |                                                                                                                                               |                                                                                                   |                                                                                                                                                                                                       |                                           |                                                                                                                           |                                              |                                                                                                 |                                                                                                                                                                                                      |                                                                                                     |                                                                                                                                                         |
| 7  |                                        |                                                      |                           |                                          |                                                                     |                                                                                                                                               |                                                                                                   |                                                                                                                                                                                                       |                                           |                                                                                                                           |                                              |                                                                                                 |                                                                                                                                                                                                      |                                                                                                     |                                                                                                                                                         |
| 8  |                                        |                                                      |                           |                                          |                                                                     |                                                                                                                                               |                                                                                                   |                                                                                                                                                                                                       |                                           |                                                                                                                           |                                              |                                                                                                 |                                                                                                                                                                                                      |                                                                                                     |                                                                                                                                                         |
| 9  |                                        |                                                      |                           |                                          |                                                                     |                                                                                                                                               |                                                                                                   |                                                                                                                                                                                                       |                                           |                                                                                                                           |                                              |                                                                                                 |                                                                                                                                                                                                      |                                                                                                     |                                                                                                                                                         |
| 10 |                                        |                                                      |                           |                                          |                                                                     |                                                                                                                                               |                                                                                                   |                                                                                                                                                                                                       |                                           |                                                                                                                           |                                              |                                                                                                 |                                                                                                                                                                                                      |                                                                                                     |                                                                                                                                                         |
| 11 |                                        |                                                      |                           |                                          |                                                                     |                                                                                                                                               |                                                                                                   |                                                                                                                                                                                                       |                                           |                                                                                                                           |                                              |                                                                                                 |                                                                                                                                                                                                      |                                                                                                     |                                                                                                                                                         |

<sup>32</sup> Fieldworker: If the household head was not available, make a note of who you have interviewed on the last page of the questionnaire

|    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|----|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
| 12 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 13 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

\*\* Please make a note below of who did you interview if the household member is not the head:

### 3. Household Livelihood Vulnerability Status

3.1 Does the household own any of the following assets? Please tick the appropriate box

| Assets                                               | Yes | No | Don't Know |
|------------------------------------------------------|-----|----|------------|
| Land                                                 |     |    |            |
| Farm                                                 |     |    |            |
| Mine                                                 |     |    |            |
| Livestock                                            |     |    |            |
| House/ Property                                      |     |    |            |
| Business                                             |     |    |            |
| Other, Specify                                       |     |    |            |
| If it is yes to the above assets, please state where |     |    |            |
|                                                      |     |    |            |

3.2 Does the household have access to the following? Please tick the appropriate box

| Indicators                   | Yes | No | Don't Know |
|------------------------------|-----|----|------------|
| Access to Electricity Supply |     |    |            |

|                                                                                                          |  |  |  |
|----------------------------------------------------------------------------------------------------------|--|--|--|
| <b>Access to Running Water Supply</b>                                                                    |  |  |  |
| <b>Access to Sewerage System (e.g. the infrastructure services etc.)</b>                                 |  |  |  |
| <b>Access to Sanitation services (e.g. bath and toilet hygiene etc.)</b>                                 |  |  |  |
| <b>Access to Roads/Transportation</b>                                                                    |  |  |  |
| <b>Access to Telephone (e.g. cell phone, house phone; fax, photocopying machine etc.)</b>                |  |  |  |
| <b>Access to Financial services (e.g. bank, ATM, e-wallet services, money market from Shoprite etc.)</b> |  |  |  |
| <b>Access to Goods produced (bakery, farming etc.)</b>                                                   |  |  |  |
| <b>Other, Specify</b>                                                                                    |  |  |  |



3.3 Does the household participate in any of the following? Please tick the appropriate box.

| Indicators                                                           | Yes | No | Don't Know |
|----------------------------------------------------------------------|-----|----|------------|
| Insurance coverage of Household goods                                |     |    |            |
| Income/Allowance                                                     |     |    |            |
| Social Grants                                                        |     |    |            |
| Food Secure Programmes (e.g. food gardening, communal services etc.) |     |    |            |
| Social Networks /Social Clubs (e.g. Stokvels, society etc.)          |     |    |            |
| Skills/Apprenticeship                                                |     |    |            |
| Other, Specify                                                       |     |    |            |

#### 4. Household Vulnerability<sup>33</sup> Groups

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<sup>33</sup> *Vulnerability* is defined as a chance that a community can/is exposed to a disaster which result in loss of life/infrastructure and other associated issues.

On a scale of 1-3, in which 1= High vulnerability<sup>34</sup>, 2= Medium vulnerability; 3 = Low vulnerability<sup>35</sup>. Please tick and rank vulnerability of the groups below:

| Vulnerable groups |                                                      | 1 = HIGH | 2 = MEDIUM | 3 = LOW |
|-------------------|------------------------------------------------------|----------|------------|---------|
| <b>a</b>          | Children (0 -18 years)                               |          |            |         |
| <b>b</b>          | Women                                                |          |            |         |
| <b>c</b>          | Men                                                  |          |            |         |
| <b>d</b>          | Elderly people                                       |          |            |         |
| <b>e</b>          | Disabled people                                      |          |            |         |
| <b>f</b>          | Immigrants (are you from South Africa or elsewhere?) |          |            |         |
| <b>g</b>          | Other specify                                        |          |            |         |

**5. Has the household been affected by any of water diseases like cholera, skin diseases, and bilharzia (skin rash) or any other? Please state below or describe the symptom(s)**

|  |
|--|
|  |
|  |
|  |
|  |

## 6. Economic and Environmental Risks in the Bekkersdal Area

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<sup>34</sup> *High vulnerability* =to households who are in critical state and would need expert assistance to recover from the impacts of shocks; *Medium Vulnerability* = to households that require some level of external assistance to overcome the given shock; *Low vulnerability*= households that can adjust to given shock without needing significant external support.

Has the household/community been affected by any of the following risks in the **last 3 years?**

Please tick appropriate box.

| Risks    |                                                                                                | 1   | 2  | 3          |
|----------|------------------------------------------------------------------------------------------------|-----|----|------------|
|          |                                                                                                | Yes | No | Don't know |
| <b>a</b> | Mining and industrial development                                                              |     |    |            |
| <b>b</b> | Informal settlements                                                                           |     |    |            |
| <b>c</b> | Uncontrolled veld fires                                                                        |     |    |            |
| <b>d</b> | Water pollution                                                                                |     |    |            |
| <b>e</b> | Inadequate sewage treatment                                                                    |     |    |            |
| <b>f</b> | Waste disposal challenges                                                                      |     |    |            |
| <b>g</b> | Flooding                                                                                       |     |    |            |
| <b>h</b> | High population density                                                                        |     |    |            |
| <b>i</b> | Inappropriate land use (e.g. building in floodplains, hillsides and close to waste dumps etc.) |     |    |            |
| <b>j</b> | Dolomite                                                                                       |     |    |            |
| <b>k</b> | Sinkholes                                                                                      |     |    |            |
| <b>l</b> | Acid mine water                                                                                |     |    |            |
| <b>m</b> | Wetlands destruction (e.g. Donaldson dam, Wonderfonteinspruit etc.)                            |     |    |            |
| <b>n</b> | Service delivery                                                                               |     |    |            |
| <b>o</b> | Land pollution                                                                                 |     |    |            |
| <b>p</b> | Dust                                                                                           |     |    |            |
| <b>q</b> | Underground mining                                                                             |     |    |            |
| <b>r</b> | Earth tremors                                                                                  |     |    |            |
| <b>s</b> | Crime (e.g. burglary, robbery or theft etc.)                                                   |     |    |            |
| <b>t</b> | Drug dealing                                                                                   |     |    |            |
| <b>u</b> | Other, specify                                                                                 |     |    |            |

**7. What is the household perception of law and order (e.g. policing) in the Bekkersdal Community with regards to disasters risk? Please state below**

|  |
|--|
|  |
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|  |

**8. Are there any social structure in place for disaster events/ to deal with disaster events in Bekkersdal and do they serve their purpose? Please state below**

|  |
|--|
|  |
|  |
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|  |

**9. Has the household experienced any disaster event in Bekkersdal? If any please state below**

|  |
|--|
|  |
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|  |

**10. Disaster Events in the Bekkersdal Area and its significance to the household**

On a scale of 1 -3<sup>36</sup>; with 1 = “very significant”, 2 = “significant” and 3 == “not significant”, how do you rate the following disaster events that have been experienced by the household in the last

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<sup>36</sup> Very significant’ = impact daily; ‘Significant’ = impact weekly and ‘Not significant’ = impact monthly or seldom.

3 years?

| Disaster Events |                                                                     | 1. Significant to household | Very Significant to the household | 2. Significant to household | 3. Not significant to the household |
|-----------------|---------------------------------------------------------------------|-----------------------------|-----------------------------------|-----------------------------|-------------------------------------|
| <b>a</b>        | Droughts                                                            |                             |                                   |                             |                                     |
| <b>b</b>        | Si Sinkholes                                                        |                             |                                   |                             |                                     |
| <b>c</b>        | Windstorms                                                          |                             |                                   |                             |                                     |
| <b>d</b>        | Earthquakes                                                         |                             |                                   |                             |                                     |
| <b>e</b>        | Mining related incidents (e.g. dust, earth tremors, sinkholes)      |                             |                                   |                             |                                     |
| <b>f</b>        | Flooding                                                            |                             |                                   |                             |                                     |
| <b>g</b>        | Fires                                                               |                             |                                   |                             |                                     |
| <b>h</b>        | Social unrests (e.g. xenophobia attacks, service delivery protests) |                             |                                   |                             |                                     |
| <b>i</b>        | Health outbreaks (e.g. cholera, malaria etc.)                       |                             |                                   |                             |                                     |
| <b>j</b>        | Other specify                                                       |                             |                                   |                             |                                     |

**11. On the risks identified in number 10 above, which is the most problematic in the Bekkersdal Area according to you, and how should it be managed or/and resolved?**

|                                                      |  |
|------------------------------------------------------|--|
|                                                      |  |
| <b>i) Most problematic issue:</b>                    |  |
|                                                      |  |
| <b>ii) How it should be managed or/and resolved:</b> |  |
|                                                      |  |

## 12. Disaster Preparedness and Prevention (Mitigation) Measures

Please indicate types of measures used by the **Households** to mitigate i.e. (preparedness and prevention measures to) the disaster risks/impacts.

|  |
|--|
|  |
|  |
|  |
|  |

13. Indicate type/s of measures used by the **Households** to cope with disaster risks/impacts i.e. how did households cope with disaster risks/impacts?

| Measures |                       | 1   | 2  | 3          |
|----------|-----------------------|-----|----|------------|
|          |                       | Yes | No | Don't know |
| <b>a</b> | Spent cash savings    |     |    |            |
| <b>b</b> | Sold assets           |     |    |            |
| <b>c</b> | Received aid          |     |    |            |
| <b>d</b> | Borrowed money        |     |    |            |
| <b>e</b> | Moved to other places |     |    |            |
| <b>f</b> | Other, specify        |     |    |            |

## 14. Response and Recovery (Adaptation) Measures

Indicate type/s of measures used by **District / Local Municipality** to adapt to disaster risks/impacts in the community. Please tick appropriate box.

| Response and Recovery |                                    | Yes | No | Don't know |
|-----------------------|------------------------------------|-----|----|------------|
| Measures              |                                    |     |    |            |
| <b>a</b>              | Predetermined evacuation plans     |     |    |            |
| <b>b</b>              | Disaster information dissemination |     |    |            |

|          |                                                                                                      |  |  |  |
|----------|------------------------------------------------------------------------------------------------------|--|--|--|
| <b>c</b> | Emergency response plans                                                                             |  |  |  |
| <b>d</b> | Early warning systems in place                                                                       |  |  |  |
| <b>e</b> | Community disaster risk practitioners                                                                |  |  |  |
| <b>f</b> | Risk assessment                                                                                      |  |  |  |
| <b>g</b> | Creation and provision of relief measures:<br>1. Shelters<br>2. Food<br>3. Medical Attention         |  |  |  |
| <b>h</b> | Rehabilitation or Replacement of Assets:<br>1. Infrastructure services<br>2. Subsidisation of houses |  |  |  |
| <b>i</b> | Other, specify                                                                                       |  |  |  |

**15. What measures do you think the household should adopt to mitigate the possible impact/s of disaster risks in Bekkersdal?**

|  |
|--|
|  |
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|  |

**16. Field Notes (Field workers)**

Please indicate any challenges you experienced on any of the questions above.

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|  |

*Thank you for your time in completing this questionnaire.*

## **APPENDIX 2: DISASTER PRACTITIONER QUESTIONNAIRE**

**A comparative analysis of the vulnerability of informal and formal households to disaster risks: The case of Bekkersdal**

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### **Background to the research**

The study under investigation is on a comparative analysis of the vulnerability of formal and informal households to disasters risks using the case of Bekkersdal, in the Westonaria Local Municipal district (WLM). Determining the level of vulnerability of households to various appearances of disaster risks could serve as a platform for comparing the vulnerability of informal and formal households. By interrogating the determinants of vulnerability and their components may enhance scientist's understanding of the differences and/or similarities in vulnerability of these households with the intention to address vulnerabilities through proper means. Through this household survey it will be possible to draw conclusions on different vulnerability levels and specified development packages on a comparative basis on informal and formal



households of Bekkersdal to disaster risks instead of a one-size-fits-all-approach which appears to be the current scenario generally.

### **Procedure**

If you agree to voluntarily participate in this study you will be invited to complete this questionnaire on a comparative analysis on the vulnerability of informal and formal households to disaster risks, and in which you will be able to share your knowledgeable experience and information on the household you represent, and on the Bekkersdal community in general. You are free to ask questions or raise concerns regarding the research to the fieldworker that will convey it to the head of the project.

### **Risks/discomforts**

There are minimal risks associated with participation in this survey. The interview may sometimes become exhausting as you answer the questions. It will take approximately 10-15 minutes to complete the questionnaire. *All information given by you will be held in strict confidence and will be used for the purpose of this study only. No personal identification will be possible when the information is used.* The leading researcher, members of the NRF-project team and the fieldworkers will consider and respect the community and participants throughout the study.

### **Benefits**

There will be no direct benefit to you from participating in this study. Your participation will assist the leading researcher, namely Ms Nomonde Madubula, in adding to the scientific body knowledge and literature through revising some of the old techniques that have been used in management and coping measures in the area of disasters and vulnerability. Your participation can further assist disaster practitioners to effectively target households that are most vulnerable to disaster risks at a formal and informal level locally. The possibility of refreshed strategies implemented, and current vulnerable methods remodelled to also cater for other critical variables, not added in previous studies, will be a key objective. Eventually this study should benefit all role players involved in terms of offering policymakers advice on the development of policy initiatives; in fast tracking the process of decision making; in improving planning and coordination as well as the prevention, mitigation, preparedness, response and

resilience to the disaster risks. The leading researcher on this particular research will inform the disaster practitioners/ community on the results at a convenient time when the NRF-research team give feedback to the community before/by 2015/16. The disaster practitioners/ community will then be free to provide even more input before the research is finalised.

### Consent

You are free to decline to participate in this study, or withdraw or stop participation at any time without any consequences or penalty. Your decision to participate or not to participate in this study will not have any influence on both your present and future status in this community.

---

**Interviewee**

---

**Signature**

---

**Date**

---

**Interviewer**

---

**Signature**

---

**Date**

## DISASTER PRACTITIONER VULNERABILITY QUESTIONNAIRE

### 1. CONTACT DETAILS

#### 1.1 Contact details

|          |                                       |  |
|----------|---------------------------------------|--|
| <b>a</b> | Name and Surname                      |  |
| <b>b</b> | Position in the District/Municipality |  |
| <b>c</b> | Ward/Area                             |  |
| <b>d</b> | Contact number (cell/tel.)            |  |

### 2. Economic and Environmental Risks in the Bekkersdal Area

Has the **West Rand District Municipality** (*Bekkersdal, in the Westonaria Local Municipality*) been affected by any of the following risks in the **last three years**? Please tick appropriate box.

| Risks    |                                                                                            | 1   | 2  | 3          |
|----------|--------------------------------------------------------------------------------------------|-----|----|------------|
|          |                                                                                            | Yes | No | Don't know |
| <b>a</b> | Mining and industrial development                                                          |     |    |            |
| <b>b</b> | Informal settlements                                                                       |     |    |            |
| <b>c</b> | Uncontrolled veld fires                                                                    |     |    |            |
| <b>d</b> | Water pollution                                                                            |     |    |            |
| <b>e</b> | Inadequate sewage treatment                                                                |     |    |            |
| <b>f</b> | Waste disposal challenges                                                                  |     |    |            |
| <b>g</b> | Flooding                                                                                   |     |    |            |
| <b>h</b> | High population density                                                                    |     |    |            |
| <b>i</b> | Inappropriate land use (e.g. building in floodplains, hillsides and close to waste dumps.) |     |    |            |
| <b>j</b> | Dolomite                                                                                   |     |    |            |
| <b>k</b> | Sinkholes                                                                                  |     |    |            |
| <b>l</b> | Acid mine water                                                                            |     |    |            |
| <b>m</b> | Wetlands destruction (e.g. Donaldson dam, Wonderfonteinspruit )                            |     |    |            |
| <b>n</b> | Service delivery                                                                           |     |    |            |
| <b>o</b> | Land pollution                                                                             |     |    |            |
| <b>p</b> | Dust                                                                                       |     |    |            |
| <b>q</b> | Underground mining                                                                         |     |    |            |
| <b>r</b> | Earth tremors                                                                              |     |    |            |
| <b>s</b> | Crime (e.g. burglary, robbery or theft )                                                   |     |    |            |
| <b>t</b> | Drug dealing                                                                               |     |    |            |
| <b>u</b> | Other, specify                                                                             |     |    |            |

**3. Are there any social structure/s in place to deal with sudden disaster events in Bekkersdal, and do they serve their purpose? Please state below**

|                                                              |
|--------------------------------------------------------------|
|                                                              |
| <b>Social structures in place? (name)</b>                    |
|                                                              |
| <b>Do the aforementioned structures serve their purpose?</b> |
|                                                              |

#### **4. Disaster Events in the Bekkersdal Area**

On a scale of 1 -3; with 1 = “very significant”<sup>37</sup>, 2 = “significant” and 3 == “not significant”, how do you rate the following disaster events that have been experienced by the **West Rand District Municipality** (Bekkersdal, in the Westonaria Local Municipality) in the last 3 years?

| Disaster Events |                                                                | 1. Very Significant | 2. Significant | 3. Not significant |
|-----------------|----------------------------------------------------------------|---------------------|----------------|--------------------|
| <b>a</b>        | Droughts                                                       |                     |                |                    |
| <b>b</b>        | Si Sinkholes                                                   |                     |                |                    |
| <b>c</b>        | Windstorms                                                     |                     |                |                    |
| <b>d</b>        | Earthquakes                                                    |                     |                |                    |
| <b>e</b>        | Mining related incidents (e.g. dust, sinkholes, earth tremors) |                     |                |                    |

---

<sup>37</sup> ‘Very significant’= impact daily; ‘Significant’ = impact weekly and ‘Not significant’ = impact monthly or seldom

|          |                                                                      |  |  |  |
|----------|----------------------------------------------------------------------|--|--|--|
| <b>f</b> | Flooding                                                             |  |  |  |
| <b>g</b> | Fires                                                                |  |  |  |
| <b>h</b> | Social unrests ( e.g. xenophobia attacks, service delivery protests) |  |  |  |
| <b>i</b> | Health outbreaks (e.g. cholera, malaria )                            |  |  |  |
| <b>j</b> | Other specify                                                        |  |  |  |

### 5. Disaster Preparedness and Prevention (Mitigation) Measures

Please indicate types of measures used by the **West Rand District Municipality** (*Bekkersdal, in the Westonaria Local Municipality*) to mitigate i.e. (preparedness and prevention measures to) the disaster risks/impacts.

|  |
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#### 5.1. Are these Disaster Preparedness and Prevention (Mitigation) Measures indicated above integrated in the Development Plans (IDP's) of the Municipality?

| Yes                                                              | No                                                                  |
|------------------------------------------------------------------|---------------------------------------------------------------------|
| If yes, please state reasons why you have adopted these measures | If no, please state reasons why you have not adopted these measures |
|                                                                  |                                                                     |
|                                                                  |                                                                     |
|                                                                  |                                                                     |
|                                                                  |                                                                     |

|  |  |
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|--|--|

## 6. Response and Recovery (Adaptation) Measures

Indicate type/s of measures are used by **West Rand District (Bekkersdal, in the Westonaria Local Municipality)** to adapt to disaster risks/impacts. Please tick appropriate box.

| Response and Recovery Measures |                                                                                                      | Yes | No | Don't know |
|--------------------------------|------------------------------------------------------------------------------------------------------|-----|----|------------|
| <b>a</b>                       | Predetermined evacuation plans                                                                       |     |    |            |
| <b>b</b>                       | Disaster information dissemination                                                                   |     |    |            |
| <b>c</b>                       | Emergency response plans                                                                             |     |    |            |
| <b>d</b>                       | Early warning systems in place                                                                       |     |    |            |
| <b>e</b>                       | Community disaster risk practitioners                                                                |     |    |            |
| <b>f</b>                       | Risk assessment                                                                                      |     |    |            |
| <b>g</b>                       | Creation and provision of relief measures:<br>1. Shelters<br>2. Food<br>3. Medical attention         |     |    |            |
| <b>h</b>                       | Rehabilitation or replacement of assets:<br>1. Infrastructure services<br>2. Subsidisation of houses |     |    |            |
| <b>i</b>                       | Other, specify                                                                                       |     |    |            |

**7. What are the challenges and risks experienced by the *West Rand District Municipality (Bekkersdal in the Westonaria Local Municipality)* in managing disaster risks?**

|  |
|--|
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**8. Any proposed solutions to question 7 above?**

|  |
|--|
|  |
|  |
|  |
|  |

*Thank you for your time in completing this questionnaire.*

**APPENDIX 3: PERMISSION TO CONDUCT RESEARCH IN BEKKERSDAL**

PROFESSOR ELIZE VAN EEDEN  
 NORTH-WEST UNIVERSITY  
 SCHOOL OF BASIC SCIENCES- VAAL TRIANGLE CAMPUS P.O. BOX 1174  
**VANDERBIJLPARK**  
 1900

Dear Professor Van Eeden,

**SUBJECT: PERMISSION TO CONDUCT RESEARCH IN BEKKERSDAL**

With reference to your e-mail dated 15 April 2013 and also our original letter dated 20 June 2012

**(copy attached)**

This is to confirm that permission is granted to your team to undertake research, as requested, with an understanding that the focus thereof will be on the Bekkersdal Community.

The Municipality's contact person is Ms Tokky Morolo and can be reached at

[tmorolo@westonaria.gov.za](mailto:tmorolo@westonaria.gov.za)



**MR TC NDLOVU**  
**MUNICIPAL MANAGER**

Looking forward with great interest towards a fruitful initiative and collaboration.  
Regards,

Westonaria Local Municipality. 2 Neptune Street, Westonaria. P O Box 19, Westonaria 1780

Tel: 011 278 3001. Fax: 011 278 3102. Website: [www.westonaria.gov.za](http://www.westonaria.gov.za)





**WESTONARIA LOCAL MUNICIPALITY**  
**OFFICE OF THE MUNICIPAL MANAGER**

20<sup>TH</sup> June 2012

PROFESSOR ELIZE VAN EEDEN  
NORTH-WEST UNIVERSITY  
SCHOOL OF BASIC SCIENCES – VAAL TRIANGLE CAMPUS  
P.O. BOX 1174  
VAN DER BIJLPARK  
1900

Dear Professor Van Eeden,

**SUBJECT: PERMISSION TO CONDUCT A PILOT RESEARCH IN BEKKERSDAL**

Your introductory presentation to the Westonaria Local Municipality on 13 June 2012 in respect of the subject matter refers.

This is to confirm that permission is granted to your team to undertake research, as requested, with an understanding that the focus thereof will be on the Bekkersdal Community.

Kindly note that as discussed and agreed, a meeting will be arranged with all the Bekkersdal Councillors as soon as they are back from recess.

The Municipality's contact persons are Ms Tokky Morolo and Mr Manie Van Brakel and can be reached at ~~011 278 3001~~ and ~~011 278 3102~~ respectively.

Looking forward with great interest towards a fruitful initiative and collaboration.

Regards,

  
**MR TC NDLOVU**  
MUNICIPAL MANAGER

## **APPENDIX 4: CONSENT FORM**

### **A comparative analysis of the vulnerability of informal and formal households to disaster risks: The case of Bekkersdal**

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#### **Background to the research**

The study under investigation is on a comparative analysis of the vulnerability of formal and informal households to disasters risks using the case of Bekkersdal, in the Westonaria Local Municipal district (WLM). Determining the level of vulnerability of households to various appearances of disaster risks could serve as a platform for comparing the vulnerability of informal and formal households. By interrogating the determinants of vulnerability and their components may enhance scientist's understanding of the differences and/or similarities in vulnerability of these households with the intention to address vulnerabilities through proper means. Through this household survey it will be possible to draw conclusions on different vulnerability levels and specified development packages on a comparative basis on informal and formal households of Bekkersdal to disaster risks instead of a one-size-fits-all-approach which appears to be the current scenario generally.

#### **Procedure**

If you agree to voluntary participate in this study you will be invited to complete this questionnaire on a comparative analysis on the vulnerability of informal and formal households to disaster risks, and in which you will be able to share your knowledgeable experience and information on the household you represent, and on the Bekkersdal community in general. You are free to ask questions or raise concerns regarding the research to the fieldworker that will convey it to the head of the project.

#### **Risks/discomforts**

There are minimal risks associated with participation in this survey. The interview may sometimes become exhausting as you answer the questions. It will take approximately

30-45 minutes to complete the questionnaire. *All information given by you will be held in strict confidence and will be used for the purpose of this study only. No personal identification will be possible when the information is used.* The leading researcher, members of the NRF-project team and the fieldworkers will consider and respect the community and participants throughout the study.

### **Benefits**

There will be no direct benefit to you from participating in this study. Your participation will assist the leading researcher, namely Ms Nomonde Madubula, in adding to the scientific body knowledge and literature through revising some of the old techniques that have been used in management and coping measures in the area of disasters and vulnerability. Your participation can further assist disaster practitioners to effectively target households that are most vulnerable to disaster risks at a formal and informal level locally. The possibility of refreshed strategies implemented, and current vulnerable methods remodelled to also cater for other critical variables, not added in previous studies, will be a key objective. Eventually this study should benefit all role players involved in terms of offering policymakers advice on the development of policy initiatives; in fast tracking the process of decision making; in improving planning and coordination as well as the prevention, mitigation, preparedness, response and resilience to the disaster risks. The leading researcher on this particular research will inform the community on the results at a convenient time when the NRF-research team give feedback to the community before/by 2015/16. The community will then be free to provide even more input before the research is finalised.

### **Consent**

You are free to decline to participate in this study or withdraw or stop participation at any time without any consequences or penalty. Your decision to participate or not to participate in this study will not have any influence on both your present and future status in this community.

|                             |                              |             |
|-----------------------------|------------------------------|-------------|
| _____                       | _____                        | _____       |
| <b>Participant name</b>     | <b>Signature</b>             | <b>Date</b> |
| _____                       | _____                        | _____       |
| <b>Fieldworker name (1)</b> | <b>Fieldworker signature</b> | <b>Date</b> |
| _____                       | _____                        | _____       |
| <b>Fieldworker name (2)</b> | <b>Fieldworker signature</b> | <b>Date</b> |

## APPENDIX 5: DECLARATION FORM ON RESEARCH ETHICS

NORTH-WEST UNIVERSITY  
YUNIBESITI YA BOKONE-BOPHIRIMA  
NOORDWES-UNIVERSITEIT  
POTCHEFSTROOM CAMPUS

Faculty of Arts



### Declaration form on research ethics

This form deals with research ethics for FH-BE-2013-0014 dissertation, thesis or a research project. The student or researcher concerned needs to fill in this form as an appendix to the research proposal.

|   |
|---|
|   |
|   |
|   |
|   |
| X |
|   |

Indicate with a cross (X) in the box the nature of research for which you fill in this form.

- Undergraduate project
- Honours Mini dissertation
- M Mini dissertation

M Dissertation  
PhD thesis  
Research project

Mark each of the 10 questions below by drawing a cross if it is applicable to your research.

Mark Yes or No inside the particular box as it applies.

Questions on the handling of participants:

|     |    |
|-----|----|
| Yes | No |
|     | X  |

1. Does the research involve vulnerable/affected participants who are coerced into participating but are unable to give informed consent? (E.g. underage children, people with learning or other psychological or physical disabilities, prisoners, people that are economically or educationally disadvantaged or other affected respondents that have to answer the questions.)

|     |    |
|-----|----|
| Yes | No |
|     | X  |

2. Will the research compromise/expose participants to discussion of intimate and/or sensitive topics? (E.g. sexual behaviour, sexual orientation, drug abuse, drinking habits, harassment, victimisation or abuse.)

|     |    |
|-----|----|
| Yes | No |
|     | X  |

3. Will the research induce physical, psychological or social stress or anxiety: or could it have negative consequences beyond the risks encountered in normal life? (E.g. invasion of privacy, loss of confidentiality, psychological trauma, indirect physical damage, embarrassment, labelling, stigmatisation, group stereotyping, questioning of values)

4 Will the research expose the participants to drastic, intrusive or potentially harmful procedures of any nature or to any form of physical or psychological intervention? (E.g. due to experimental research designs entailing far-reaching interventions.)

|     |    |
|-----|----|
| Yes | No |
| X   |    |

5. Does the research involve participants without their knowledge and consent? (E.g. observing people without them being aware of this.)

|     |    |
|-----|----|
| Yes | No |
|     | X  |

Questions concerning the research process:

|     |    |
|-----|----|
| Yes | No |
| X   |    |

6 Will the research require the co-operation of a (such as a school principal, head of an institution, head of a department, manager, traditional leader, community to gain the initial access to the groups or individuals that you aim to involve?

In this research, interviews will be conducted with members of the community, ward committees, councillors including government departments and head of the units on disaster management in the province and the local area. Not only that, secondary information will also be solicited from government officials as supporting documents to the interviews conducted.

7. Will the research record participants' personal details (name and contact information) so as to be available *for* follow-up? when the follow-up interviews form part of H1e

|     |    |
|-----|----|
| Yes | No |
| X   |    |

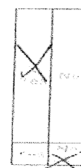
8. Will the researcher offer the participants financial instruments (other than the acceptable expenditures and compensation for their time) or any means of coercion?



**Questions concerning the impact on the NWU and the institutions concerned:**

9. Does the research involve any students or staff of the NWU?

Yes, the research forms part of the IMD research in the Bekkersdal area where previous research relating to environmental health and wellbeing of mining communities have been conducted by previous researchers/students of the NWU. Further, the research will be conducted according to the strict guidelines of the NWU. Ethical clearance and permission has been granted to the Community Engagement Integrative Multidisciplinary project related to the Environmental Health and Wellbeing of Mining Communities as NRF-funded project to conduct research in Bekkersdal.



10. Is there any danger of the research having a detrimental effect on or tarnishing the image of the NWU, the relevant academic entity, your employer, or any other institution that is involved or is taking part in the research?

If you have answered **No** to all questions, sign the declaration below and submit the completed and signed form as an appendix to your research proposal.

If you answered **Yes** to any of these questions, also sign the declaration below. Thereafter submit the completed and signed form as an appendix to your research proposal. Because your research deals with ethical aspects, you will also need to describe more fully how you plan to address the ethical aspects raised by your proposal. You will need to explain these ethical aspects on the Research Ethics application form, which you can obtain from the following website of the university: <https://intranet.nwu.ac.za/opencms/export/intranet/html/en/in-im-rs/researchethics/index.html>.

The research ethics committee concerned will then consider your explanation. If the committee approves your proposal with the accompanying explanation, you can continue your research. Otherwise your research proposal will be referred back for you to rectify the issue. Your proposal can also be rejected.

Please note that it remains your responsibility to follow the NWU's guidelines for ethical research which are explained in the *Manual for Postgraduate Studies*. This also applies to any academic or professional guidelines that could concern your research. It implies, for example, providing respondents with the appropriate documentation to gather information and completing letters of consent, where applicable. This also requires ensuring that complete confidentiality or protection will be maintained when you store the data.

Any significant change in the research question, design or conduct over the course of the research must be notified to the supervisor. Keep in mind that such a change could make it necessary to fill in a new form.

**Declaration by the applicant:**

I have read the NWU's *Manual for Postgraduate Studies* and have acquainted myself with the guidelines for research ethics contained in it. In light of this I declare that I will conduct my research according to ethically acceptable norms. I give the undertaking that, when I present any research under my own name, this indeed will be my own research. I will also insert proper references in the research (in the text as well as the bibliography) for each quotation and contribution obtained from other sources.

Applicant:

Name:

Number:

Signature:

Date:

NOMONDE MADUBULA

Student

number/Staff

Study leader/Promoter/Head of research

Faculty of Arts: Declaration form on research ethics

2

PO Box 1174, Vanderbijlpark  
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**Faculty of Humanities**

Tel: 016-91003441

Email: [Chrizanne.vaneeden@nwu.ac.za](mailto:Chrizanne.vaneeden@nwu.ac.za)

2 September 2020



Dear Prof. E. van Eeden,

**ETHICS APPROVAL EXTENDED**

This letter serves to indicate that your request for extension of the ethics approval of the Bekkersdal project was granted by the Basic and Social Sciences Research Ethics Committee of the Faculty of Humanities:

**Faculty application number:**

FH-BE-2013-0014

**Project Leader:**

Prof. E. van Eeden

**Applicant:**

Prof. E. van Eeden

**Project title:** Broader research focus: Multidisciplinary focused research on the health and well-being status of mining communities.

Project Theme: Exploring integrative multidisciplinary focused research on the health and well-being status of mining communities: The case of Bekkersdal, Westonaria

**Meeting date:**

30 August 2020

The application was initially in 2013 and 2015 and extension is now granted by BaSSREC until 31<sup>st</sup> December

2020 to allow a PhD student to complete a study based on the Bekkersdal project.

The title of the study is: *A Comparative Analysis of the Vulnerability of Informal and Formal Households to*

*Disaster Risks: The Case of Bekkersdal* and the student is Ms Nomonde Madubula (Student no 24705314). BaSSREC wishes you and the student well in the completion of the study.



Yours sincerely

Chrizanne van Eeden

Chair: BaSSREC.

Original details: (10057013) P:\Daleen\BaSSREC\Prof C van Eeden-letter.docm  
10 September 2019

File reference: 9.1.5

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