6 Risk assessment

6.1 Introduction and Context

Most of the western urban area (Ikageng/ Mohadin/Promosa areas) is partially underlain by dolomite (North West Department of Agriculture, 2009). Although only partially underlain by dolomite many of the urban areas are located on dolomite areas that can be classified as dangerous to very dangerous (Inherent Risk Classes 5-8). Along with the exposure to the dolomite hazard, some of the communities inhabiting these areas can also be considered as some of the most economic and socially vulnerable peoples in the Tlokwe Local Municipality. The combination of socio-economic vulnerability and exposure to the dolomite hazard heightens certain communities' disaster risk. It is the purpose of the study to determine which communities within the Tlokwe Local Municipality can be considered as the most at-risk through the process of disaster risk assessment.

The process of disaster risk assessment forms part of the legal imperative laid down by the Disaster Management Act (57 of 2002), which came into effect on 15 January 2003 (Van Niekerk, 2006). The Disaster Management Act (57 of 2002) has a distinct disaster risk reduction focus, and places considerable emphasis on the development of adequate structures, planning and integrated and coordinated disaster management activities on all tiers of government. The Act further establishes the function of disaster management within the South African public sector (Van Niekerk, 2006).

Along with the Disaster Management Act (57 of 2002) a National Disaster Management Framework (2005) was created. The National Disaster Management Framework (2005) is a legal instrument specified by the Disaster Management Act (57 of 2002) to address such needs for consistency across multiple interest groups, by providing a coherent, transparent and inclusive policy on disaster risk management appropriate for the Republic as a whole.

The Act's requirements for priority setting, with respect to disasters likely to affect South Africa, are set out in sections 20, 33 and 47. These sections underscore the importance of disaster risk assessment, to guide national, provincial and municipal disaster risk reduction efforts, including disaster risk management planning. KPA2: Disaster Risk Assessment outlines the requirements for implementing disaster risk assessment and monitoring by organs of state, within all spheres of government. Furthermore, it shows that the outcomes of disaster risk assessments should directly inform the development of disaster risk management plans (National Disaster Management Framework, 2005)

6.2 Defining Disaster Risk

Disaster risk is defined as the probability of harmful consequences, or expected losses (deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged), resulting from interactions between natural or human-induced hazards and vulnerable conditions (United Nations International Strategy for Disaster (UNISDR), 2004).

What is crucial to understand about risk, is that it is innate to, or can be shaped by, social systems and economic conditions (UNISDR, 2004). For example, due to rising fuel prices, poor workers have to move closer to their places of work. This might put them in a situation where they might have built their homes in risky areas like flood plains or unstable dolomite areas, as is the case in Tlokwe Local Municipality. Thus it is clear that risk is a function of people’s exposure to hazards (Enarson, 2000)

Even when people are aware of risks, they are less likely to expend effort on something that might happen (or might not), perhaps sometime in the future, than they are to meet more immediate needs such as providing for food, water and electricity (Abromovitz, 2001). Therefore great care should be taken to communicate to identified communities the clear and present dangers that they face with regards to dolomite hazards.

6.3 Methodology

During this study, a theoretical model is built by establishing the relevant aspects (and research gaps) to be considered in developing a DRMS for the Tlokwe City Council.

Disaster risk assessment is the first step in planning an effective disaster risk reduction programme. It examines the likelihood and outcomes of expected hazard events, including the vulnerability conditions that increase the chances of loss. The following section will explain the methodology which was followed in the disaster risk assessment process as it relates to dolomite in the Tlokwe Local Municipality.

Step 1: Identify and describe the disaster risk(s)

This initial stage involved identifying the specific disaster risk to be assessed. This was done by identifying and describing each individual hazard, with respect to its frequency, magnitude, speed of onset, affected area and duration. During this process vulnerability was quantified in order to determine susceptibilities and capacities. This was done by describing the vulnerability of people, infrastructure (including homes and dwellings), services, economic activities and natural resources exposed to the hazard. Estimations on the likely losses resulting from the action of the hazard on those that are vulnerable were made in order to evaluate likely consequences or impacts. The capacities, methods and resources already available to manage the risk were identified. The effectiveness of these capacities was assessed, as well as gaps, inconsistencies and inefficiencies in government departments and other relevant agencies (National Disaster Management Framework, 2005).

Stage 2: Analyse the disaster risk(s)

The second stage involved analysing the disaster risk. During this stage an estimation was made on the level of risk associated with a specific threat to determine whether the resulting risk is a priority or not. The estimation of the level of risk was done by matching the likelihood of a hazard or disaster with its expected impact or consequences. This process allows different threats to be compared for the purpose of priority setting (National Disaster Management Framework, 2005).

Stage 3: Evaluate the disaster risk(s)

This stage involved further prioritisation of disaster risks when there are multiple threats to assess. When several threats are assessed at the same level of risk, limited resources and budgets require that they be prioritised even further. This process of risk evaluation is necessary because it is not possible to address all disaster risks at the same time (National Disaster Management Framework, 2005).

Stage 4: Monitoring of disaster risk reduction initiatives, updating and dissemination of disaster risk assessment information

This stage involves the ongoing monitoring to measure the effectiveness of disaster risk reduction initiatives, identify changing patterns and new developments in risk profiles, as well as updating and dissemination of information for the purpose of disaster risk management planning (National Disaster Management Framework, 2005). This final stage of the assessment will not form part of this assessment but is a crucial aspect which the Tlokwe Local Municipality must consider in the successful management of its dolomite disaster risk.

6.4 Vulnerability and its application to Tlokwe Local Municipality

Vulnerability can be defined as the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard event (Wisner *et al.*, 2004). A mistake that is often made when describing vulnerability is the sense that only the poor are vulnerable. This is a very simplistic and incorrect way of understanding vulnerability (Yodmani, 2001). Whilst the poor are often most affected by disasters, poverty can only be viewed as one spoke in the wheel of vulnerability.

People’s vulnerability is determined by a complex array of socio-economic factors such as class, ethnicity, community structure, community decision making processes and political issues that determine poor people’s vulnerability (Yodmani, 2001; Wisner *et al*., 2004; Arya *et al*., 2005)

In the case of Tlokwe Local Municipality several socio-economic factors can be identified that contribute to the overall vulnerability of communities, especially those situated in areas underlain by dolomite rock formations. According to statistics from the Potchefstroom Basic Socio Survey (2004), 66 483 citizens (Table 6-1) inhabit areas which are either 80% or 10 % underlain by dolomite rock formations.

Table 6-1*:* Dolomite percentages per ward (adapted from Potchefstroom basic socio survey, 2004)

WARD	Probability of Dolomite in ward	Number of Citizens
7	80% and 10%	4 477
13	80% and 10%	3 884
9	80% and 10%	10 094
11	80%	8 517
16	80% and 10%	7 034
19	80% and 10%	7 646
14	80% and 10%	6 628
18	80% and 10%	6 055
21	80% and 10%	5352
TOTAL		66 483

Due to the lack of up to date population statistics it is difficult to predict how many citizens inhabit the above-mentioned areas currently (February 2010), especially those demarcated as high or medium risk dolomite areas. This lack of up to date statistics could greatly inhibit the formulation of adequate plans to manage, respond and mitigate problems associated with dolomite formations. In-spite of this lack of population information, an informal population count was done for wards 10 and 16, which are both situated on composite high and medium risk areas. This estimation was done by counting the houses on the map and assigning 5 members to each house. Following this technique population of ward 10, living on high to medium risk dolomite areas, is estimated at about 3000 and ward 16 at 7034. It should be clear that both these areas need urgent attention.

The areas identified are also characterised by high levels of unemployment, poverty and food insecurity (Tlokwe City Council, 2009). It is estimated that some of these areas have an average unemployment rate of 35% (Potchefstroom Basic Socio Survey, 2004). More significantly, these statistics indicate that the unemployment rate for females (20.4%), was almost double that of males (11.2%). With regards to monthly income it is estimated that at least 50 % of households earn R1 500 per month or less (Tlokwe City Council, 2009). Furthermore within these areas 55 % of inhabitants depend on social grants, pension, remittance and informal business activities as their main sources of income (Tlokwe City Council, 2009). This clear lack of financial resources experienced by communities, and especially women, will leave them without the means to reconstruct their livelihoods following possible disaster events and this in turn will make them even more vulnerable to subsequent hazard events (Wisner *et al.*, 2004).

Several other social problems that contribute to the overall vulnerability of relevant communities have been identified in the Tlokwe Local Muncipality IDP Review 2009-2010. Education levels in the identified areas are generally low with less than 21% of the population having a grade 12 or higher qualification and with a further 12,8% of the population having no schooling (Tlokwe City Council, 2009). Furthermore a high prevalence of HIV and substance abuse in informal settlements will further increase vulnerability (Tlokwe City Council, 2009).

With regards to critical infrastructure, several medical facilities can be identified which are located in areas underlain with dolomite. These facilities include Promosa, Mohadin (Mohadin extension 1) Boiki Thapi (Ikageng extension 1), Top

City (Ikageng extension 4), Lesego (Ikageng extension 1) and Steve Tshwete clinics (location unknown) (Tlokwe City Council, 2009). Damage caused by sinkhole formation to any of the identified clinics will greatly increase the vulnerability of the inhabitants which they serve (which are often multiple wards) as well as put extra pressure on other medical facilities, which might not be able to handle the influx of additional patients.

Other critical infrastructure can also be at risk from sinkhole formation. Specifically bulk water supply and general water supply are at greatest risk in wards 10 (Ikageng) and 16 (Ikageng, Lusaka) that are both underlain by medium and high-risk dolomite areas. Damage to any of these water supplies could also destabilise the dolomite in the identified wards even further.

Some road infrastructure is also at risk. In this regard main roads leading into wards, 9 (Mohadin), 10 (Ikageng) and 16 (Ikageng, Lusaka) are situated on high-risk dolomite areas. Formation of sinkholes in these areas will cause significant and costly damage to Ikageng's road infrastructure, and might also hamper emergency response efforts.

6.5 Assessment

In order to conduct an effective assessment of disaster risk assessment relating to the dolomite hazards in the Tlokwe Local Municipality it is crucial to have a basic understanding of the inherent risk classification of dolomite rock formations. Dolomite rock formations are classified on a risk scale of 1-8. Dolomite rock formation categorised in risk category 1 are considered low risk whilst those categorised as category 8 are considered extremely high risk dolomite formations (Buttrick *et al*., 2011).

Lower Inherent Risk Class numbers (1-2) are deemed suitable for all types of development (including residential development), whereas Inherent Risk Classes 3 and 4 are considered suitable for selected residential development. Inherent Risk Classes 6 and 7 are considered unsuitable for residential development but suitable for commercial and light dry industrial development and Inherent Risk Class 8 are only considered suitable for nature reserves and parkland (Buttrick *et al*., 2011).

For the purpose of this study, risk ratings (i.e. high, medium or low) are assigned to the areas with:

- an indicated risk based on the probable occurrence of dolomite, and
- a measured risk based on the proven occurrence of dolomite.

The assigned ratings are summarised in Table 6-2 and Table 6-3 below.

Table 6-2: Risk rating for areas with an indicated risk based on the probable occurrence of dolomite

Indicated Risk based on the probable occurrence of dolomite	
Risk	**Rating**
Dolomite	High
Dolomite < 60m	High
20%	Medium
< 20%	Low

Table 6-3: Risk rating for areas with a measured risk based on the proven occurrence of dolomite

Measured Risk based on the proven occurrence of dolomite	
Inherent Risk Class	**Rating**
1	Low
2 – 4	Medium
5 – 8	High

To get a clearer picture of the risk that communities face with regards to dolomite it is necessary to quantify the risk faced by using the formula of:

R (risk) = H (hazard) + V (vulnerability).

In this formula, hazard is represented by the risk classes of dolomite discussed above (i.e. physical factors). The higher the risk class, the higher the hazard faced by the community, thus high-risk dolomite will be quantified as 3, medium-risk as 2 and low-risk as 1, as indicated in Table 6-4.

Table 6-4: Hazard ratings for different levels of risk associated with dolomite

Physical Factors (Hazard)	
Risk	**Rating**
Low	1
Medium	2
High	3

Vulnerability in this case relates to the state of water infrastructure in communities (i.e. anthropogenic factors). It is important to take note that this vulnerability is in addition to the social vulnerabilities such as unemployment discussed earlier, but differs in the sense that it focuses on the vulnerable elements that could best contribute to the formation of sinkholes. In this regard the failure of water pipes or leaking communal taps is most likely to speed up the process of sinkhole formation. For the purpose of quantification water infrastructure is divided into different levels, ranging from very old to new infrastructure (Table 6-5). Subsequently water infrastructure will be quantified as indicated in Table 6-5:

Table 6-5: Range of water infrastructure

Anthropogenic Factors (Vulnerability)	
Type of infrastructure	**Rating**
Dolomite compliant water infrastructure	0
New water infrastructure (<5 years)	1
Mixed mostly new and some old water infrastructure (>15 years)	1
Temporary water infrastructure	2
Mixed mostly old and some new water infrastructure (> 20 years)	2
Very old water infrastructure (> 35 years)	3

When an area is found to be situated on both a high-risk dolomite area as well as an area with old water infrastructure, that area automatically becomes a high-risk area that should receive priority when intervention measures are formulated.

Areas with little or no information pose the highest risk and necessitates urgent further research in order to be able to quantify the risk.

With regards to quantifications of risk according to age of water infrastructure the following can be observed in the study area, as presented in Figure 6-1.

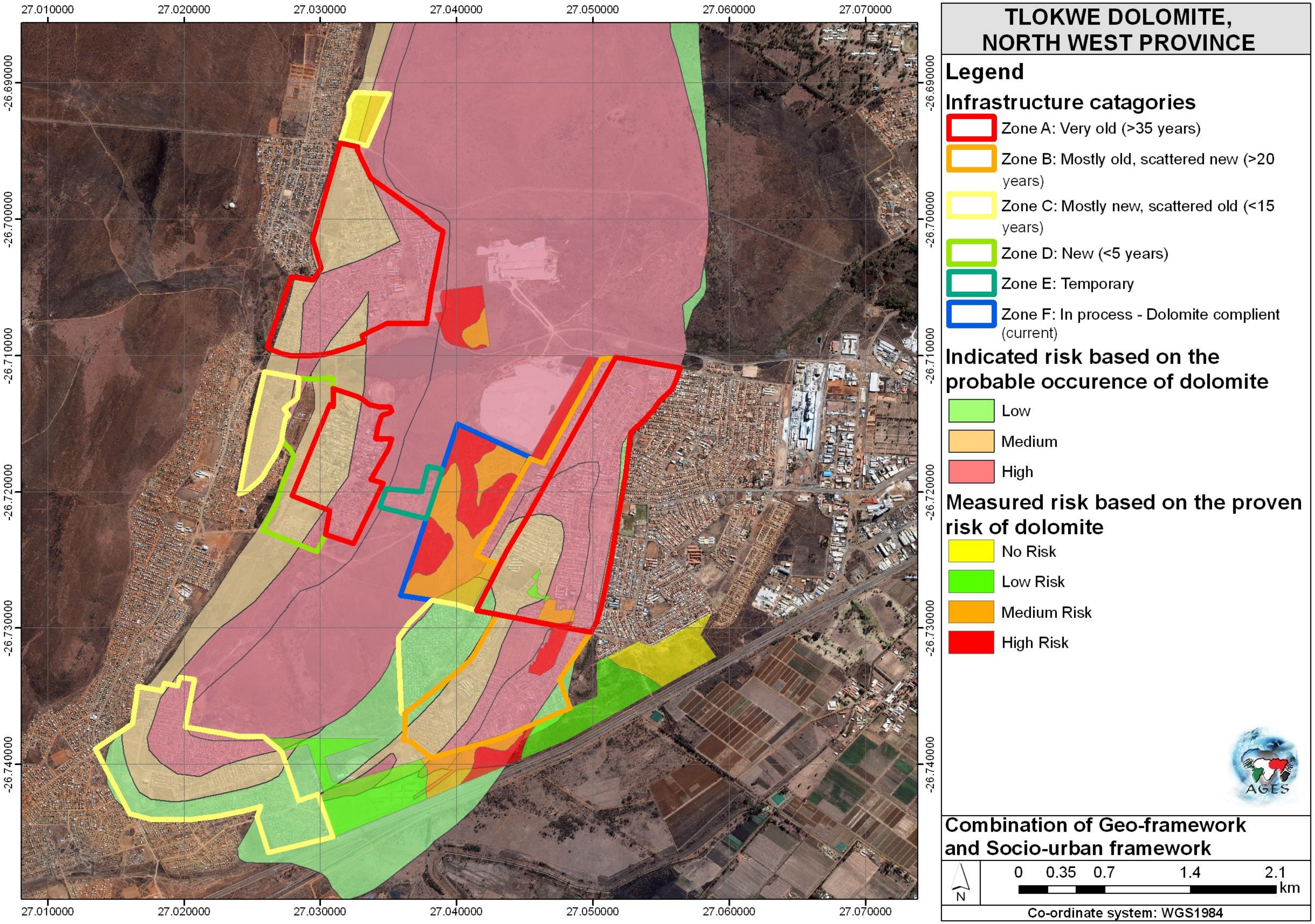


Figure 6-1: Combination of geo-framework and socio-urban framework

The western areas of ward 11 (Ikageng extension 1), ward 12 (Ikageng) and ward 14 (Ikageng) and northern areas of ward 16 (Ikageng, Lusaka) are situated on high-risk dolomite areas, or areas without relevant data, as well as being underlain by very old (35 years plus) water infrastructure. Thus the aggregate risk score for the area will be 6 (3 for high-risk dolomite/lacking information + 3 for old water infrastructure). The same risk classification can be related to the south-eastern half of Mohadin and Mohadin extension 1 (ward 9) and south-eastern parts of Promosa (ward 9&13) and Promosa extension 1(ward 13).

Risk areas quantified as 5 were identified in the following areas. The south-western half of Mohadin and Mohadin extension 1 (ward 9) and south-western parts of Promosa (ward 9+13) and Promosa extension 1 (ward 13). Both these areas have a medium possibility of being underlain by dolomite (2 points) and also has very old water infrastructure (3). Other instances of level 5 risk can also be identified in the western border regions of Ikageng extension 1, central regions of Lusaka (ward 16) and eastern parts of Ikageng extension 4. These areas are underlain by possible high-risk dolomite and mixed old and new water infrastructure. The final instance of level 5 risk can be identified on the western border of ward 10 and Mohadin extension 1, which is underlain by possible high-risk dolomite and temporary water infrastructure.

A level 4 risk area has been identified in the northern part of ward 18 and includes parts of Ikageng extension 2 and 3 as well as Sarafina extension 2. Small parts (mostly on the western edge) of Ikageng extension 4 (ward 16) can also be classified in this risk class. Possible high-risk dolomite, as well as a mixture of mostly old and some new water infrastructure underlies all these areas.

Level 3 risk areas have been identified in the south-east of Promosa extension 3, south western parts of Promosa extension 1, western parts of Ikageng extension 7, and central parts of Ikageng extensions 2 and 3 (ward 18). All these areas are underlain by possible medium-risk dolomite as well as a mixture of mostly new and some old water infrastructure. Another instance of level 3 risk can be observed in northern and central regions of ward 10. Although this area has water infrastructure that can be classified as dolomite compliant, it is still situated on an area with confirmed instances of high-risk dolomite.

Level 2 risk area has been identified in central and southern regions of Ikageng extension 2 (ward 18), northern regions of Ikageng extension 5, north-western parts of Top City extension 4 (Ward 19) and western parts of Ikageng extension 4 (Ward 16). Another instance of level 2 risk can also be observed in central and southern regions of ward 10. Although this area has water infrastructure that can be classified as dolomite compliant, it is still situated on an area with confirmed instances of medium-risk dolomite.

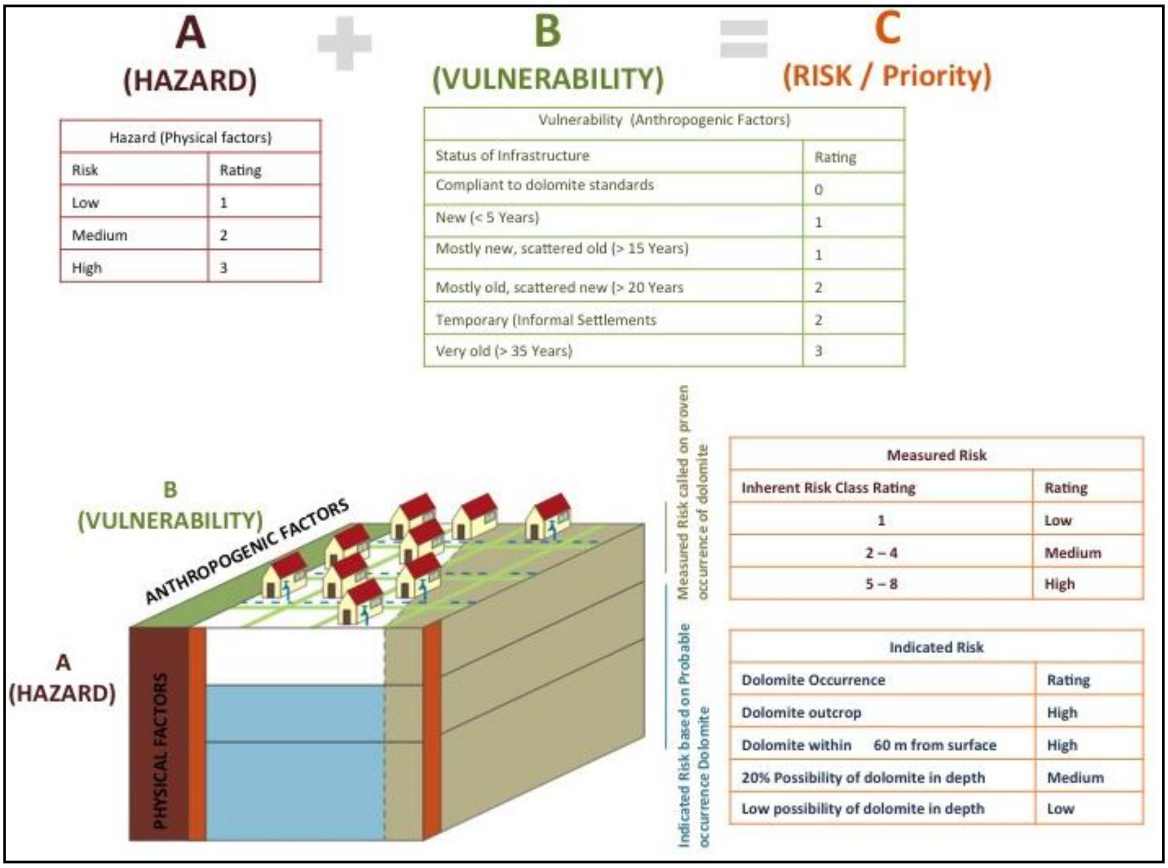
Table 6-6 indicates the calculated disaster risk scores for the settlements.

Based on the disaster risk scores, priority focus areas were identified and ranked for the study area. These areas are presented in Figure 6-3. Further actions for each of the priority focus areas are summarised in the next section in preparation to a DRMS.

Table 6-6: Calculated Disaster Risk Scores

SETTLEMENT	HAZARD (+)	VULNERABILITY (=)	RISK SCORE
Ikageng extension 1 (west),ward 12,ward 14, Ikageng, Lusaka (north), Mohadin extension 1 (south-east), Promosa:wards 9+13 (south east), Promosa exstension 1 (south east)	Possible high-risk dolomite area (+3)	Very old water infrastructure (+3)	6
Mohadin and Mohadin extension 1 (south west), Promosa (ward 9+13) and Promosa extension 1 (south-western parts), Ikageng extension 1 (western border), central regions of Lusaka (ward 16), eastern parts of Ikageng extension 4, western border of ward 10 and Mohadin extension 1	Possible medium-risk dolomite area (+2) Or Possible High-Risk dolomite (+3)	Very old water infrastructure (+3) Or Mixed mostly old some new water infrastructure (+2)	5
Northern part of ward 18 (Ikageng extension 2, 3, Sarafina extension 2), western edge) of Ikageng extension 4 (ward 16)	High-Risk Dolomite area (+3)	Mixed mostly new some old water infrastructure (+1)	4
South-east of Promosa extension 3, south western parts of Promosa extension 1, western parts of Ikageng extension 7, and central parts of Ikageng extensions 2 and 3 (ward 18), central regions of ward 10	Medium risk Dolomite (+2) Or High-risk dolomite area (+3)	Mixed mostly new some old water infrastructure (+1) Or Dolomite Compliant (+0)	3
Ikageng extension 2 (ward 18), northern regions of Ikageng extension 5, north-western parts of Top City extension 4 (Ward 19) and western parts of Ikageng extension, central and southern regions of ward 10	Low Risk dolomite (+1) Or Medium dolomite risk (+2)	Mixed mostly new some old water infrastructure (+1) Or Dolomite Compliant (+0)	2

Figure 6-2 illustrates the process of prioritisation:



Hazard (Physical factors)	
Risk	Rating
Low	1
Medium	2
High	3

Vulnerability (Anthropogenic Factors)	
Status of Infrastructure	Rating
Compliant to dolomite standards	0
New (< 5 Years)	1
Mostly new, scattered old (> 15 Years)	1
Mostly old, scattered new (> 20 Years	2
Temporary (Informal Settlements	2
Very old (> 35 Years)	3

Measured Risk	
Inherent Risk Class Rating	Rating
1	Low
2 – 4	Medium
5 – 8	High

Indicated Risk	
Dolomite Occurrence	Rating
Dolomite outcrop	High
Dolomite within 60 m from surface	High
20% Possibility of dolomite in depth	Medium
Low possibility of dolomite in depth	Low

Figure 6-2: Process of prioritisation

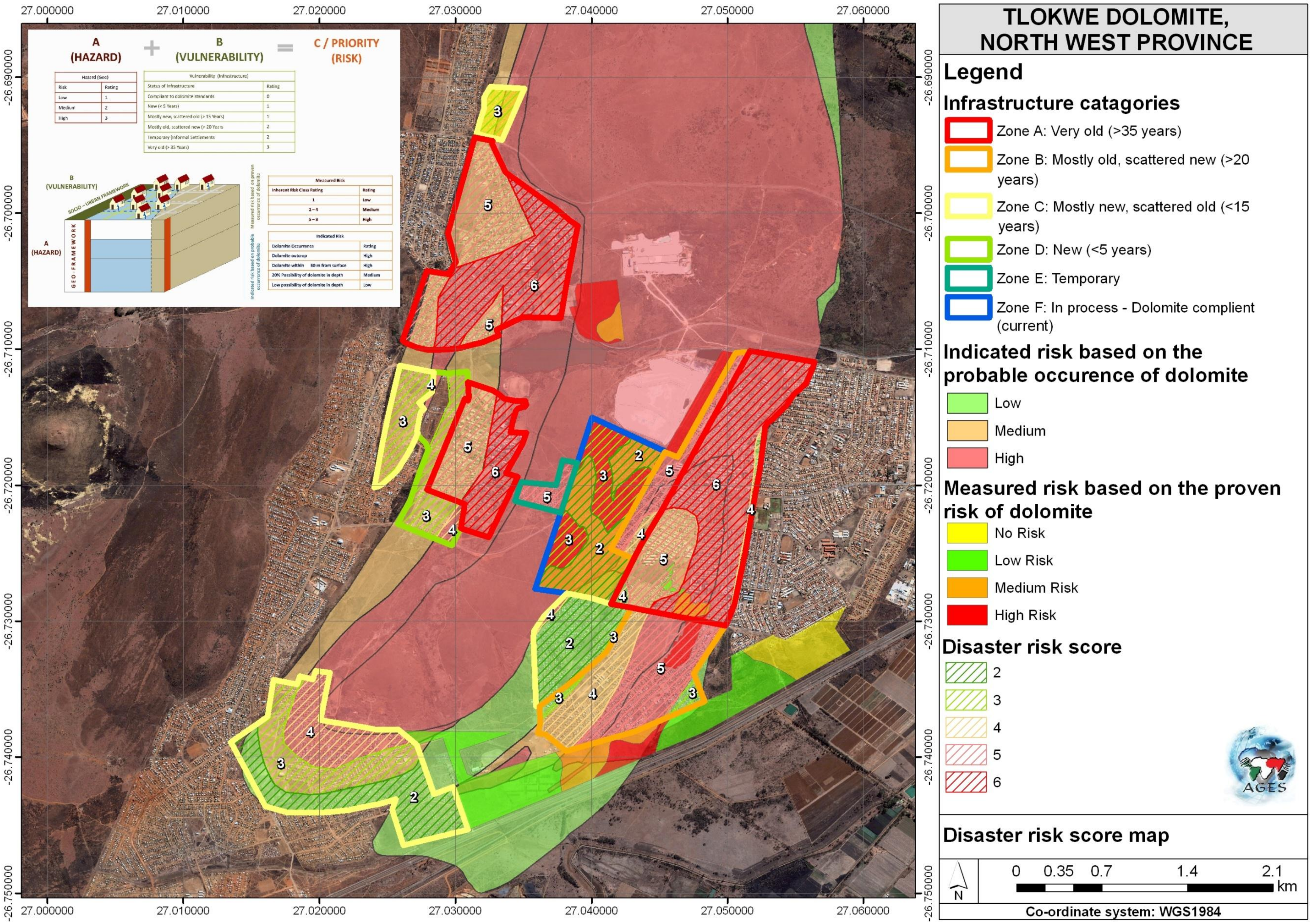


Figure 6-3: Disaster risk score map

6.6 *Prioritisation*

Table 6-7: Prioritisation based on disaster risk scores

RISK SCORE	SETTLEMENT (S)	RECOMMENDATIONS
6	Ikageng extension 1 (west),ward 12,ward 14, Ikageng, Lusaka (north), Mohadin extension 1 (south-east), Promosa:wards 9+13 (south east), Promosa exstension 1 (south east)	Urgent studies are needed to determine the exact extent of dolomite disaster risk in the area
5	Mohadin and Mohadin extension 1 (south west), Promosa (ward 9+13) and Promosa extension 1 (south-western parts), Ikageng extension 1 (western border), central regions of Lusaka (ward 16), eastern parts of Ikageng extension 4, western border of ward 10 and Mohadin extension 1	Urgent studies are needed to determine the exact extent of dolomite disaster risk in the area
4	Northern part of ward 18 (Ikageng extension 2, 3, Sarafina extension 2), western edge) of Ikageng extension 4 (ward 16)	Detailed studies on the exact degree of dolomite risk should be conducted in these areas as soon as possible
3	South-east of Promosa extension 3, south western parts of Promosa extension 1, western parts of Ikageng extension 7, and central parts of Ikageng extensions 2 and 3 (ward 18), central regions of ward 10	Some processes should be initiated, whereby which further studies on dolomite in identified areas should be carried out in the near future
2	Ikageng extension 2 (ward 18), northern regions of Ikageng extension 5, north-western parts of Top City extension 4 (Ward 19) and western parts of Ikageng extension, central and southern regions of ward 10	Although this area is not as high a priority area as others, it should not be forgotten and further studies should be conducted after studies on priority areas have finished.

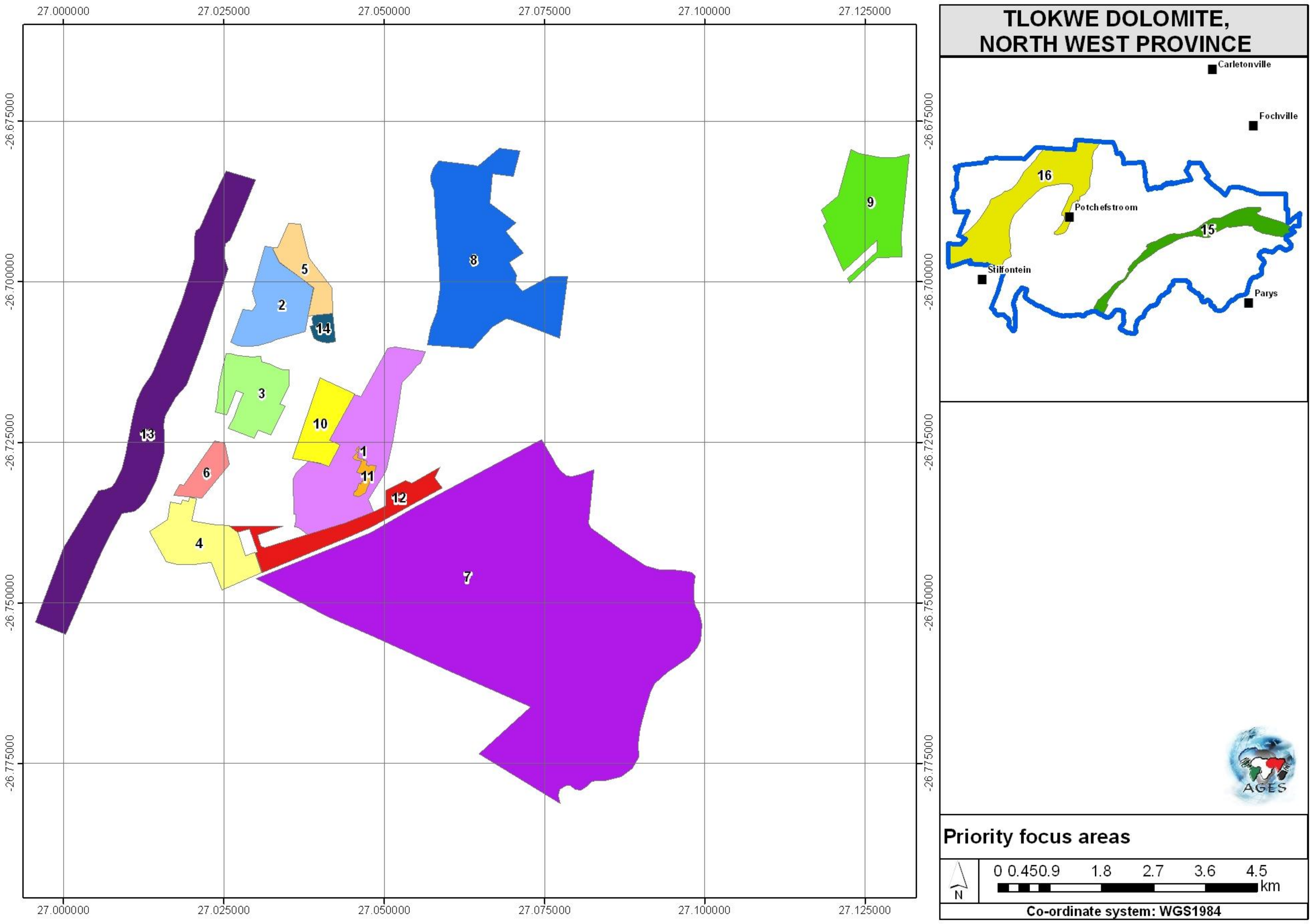


Figure 6-4: Priority focus area

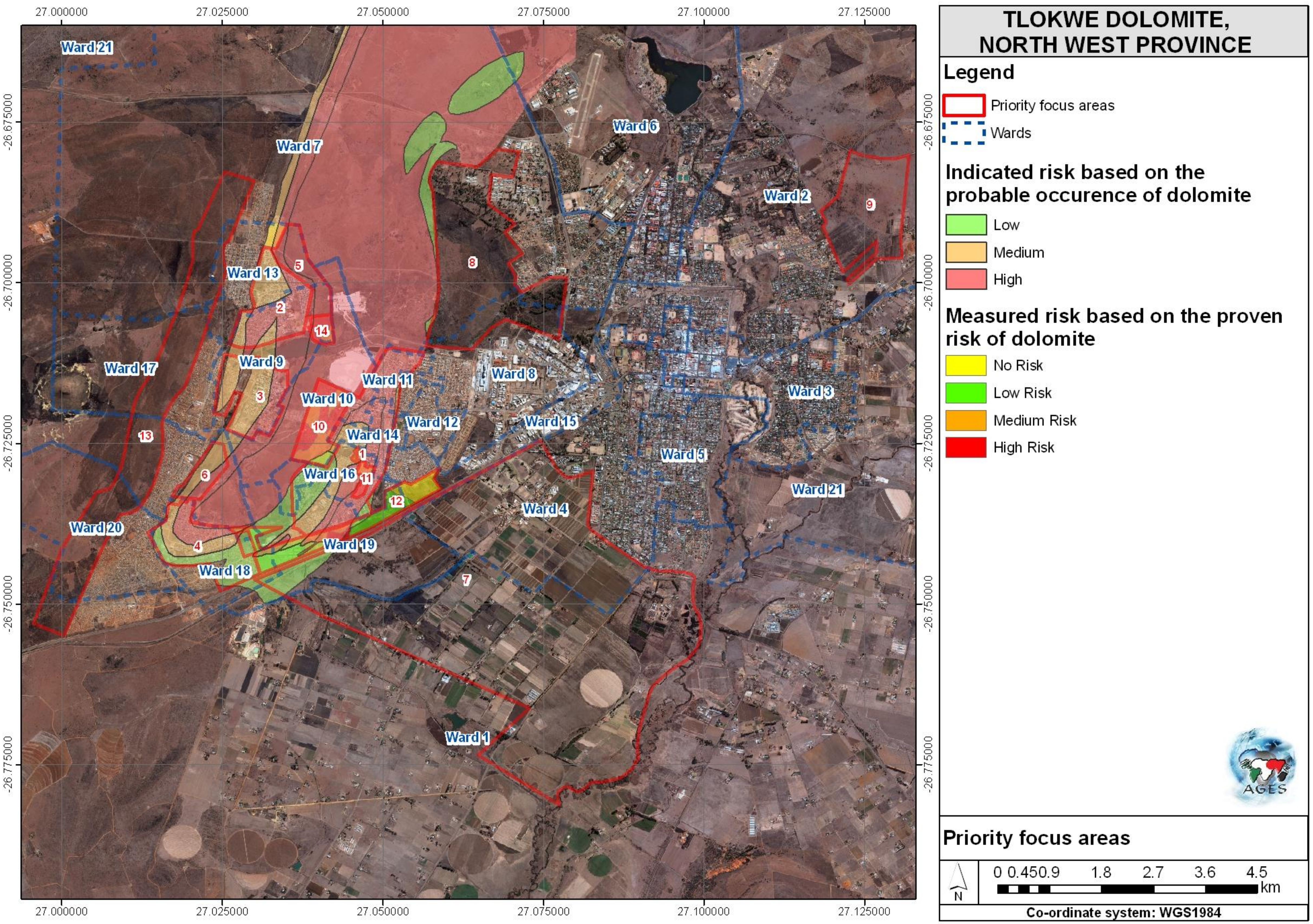


Figure 6-5: Priority focus area with indicated and measured risk

Figure 6-6 schematically indicates the result of the risk obtained when the physical factors and anthropogenic factors are combined. The idea for effective risk management is to implement measures in order to get the overall risk as acceptable as possible, as part of a DRMS.

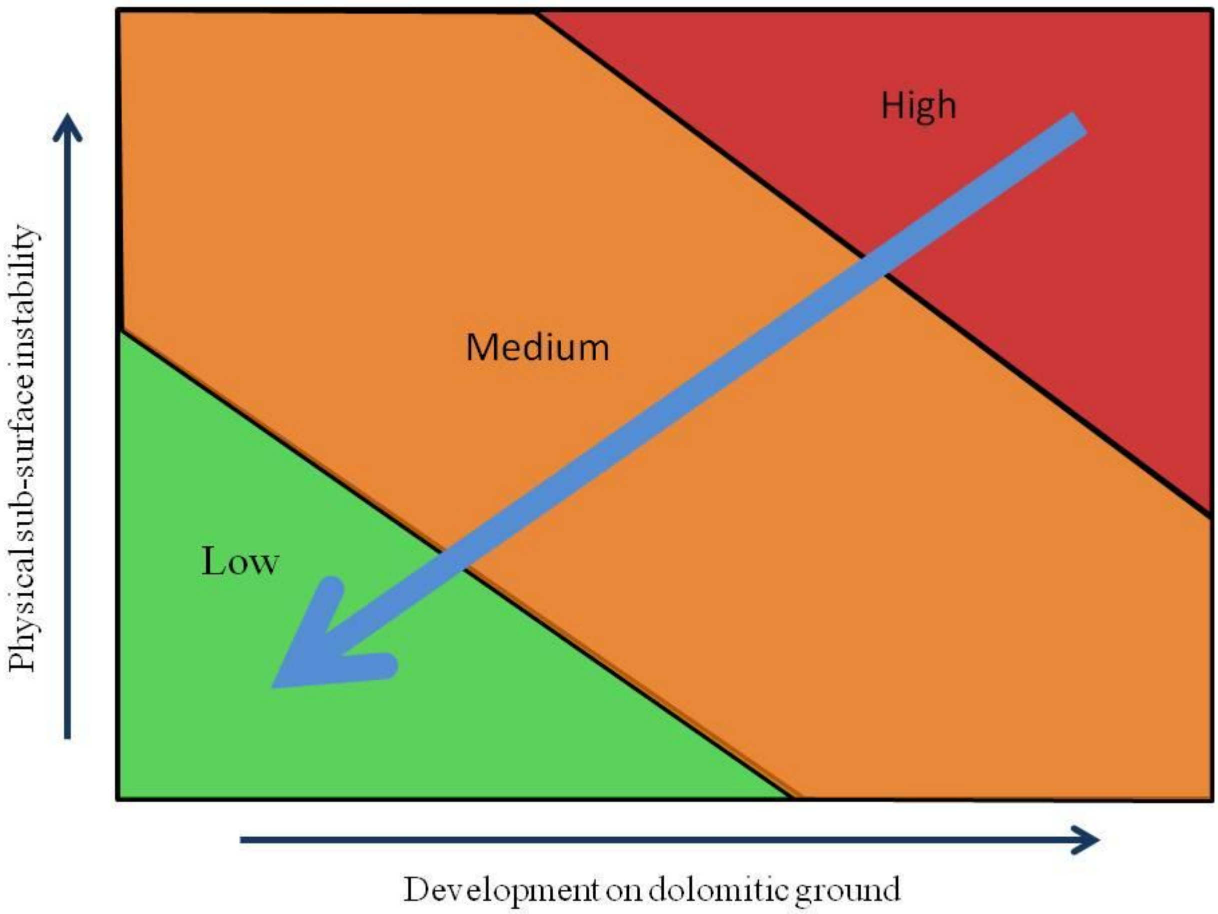


Figure 6-6: Effect of development on physical sub-surface instability.