SPATIO-TEMPORAL TRENDS FOR LONG-LASTING CONTEMPORARY SNOW IN LESOTHO: IMPLICATIONS FOR HUMAN AND LIVESTOCK VULNERABILITY

Jonathan Harris Linde

0307554R

A dissertation submitted to the Faculty of Science, University of the Witwatersrand, in fulfillment of the requirements for the degree of Master of Science.

Johannesburg
- 2011 -

DECLARATION

I declare that this dissertation is my own, original work, except where otherwise acknowledged. It is being submitted for the degree of MSc to the University of the Witwatersrand, Johannesburg. I have not submitted it previously, for the purposes of obtaining any degree, qualification or otherwise at any other university.

Jonathan Linde

Date

ABSTRACT

Prolonged snow cover in Lesotho frequently results in human and livestock deaths, due to isolation and exposure. MODIS Rapid Response imagery is emerging as an important source of near real-time data for global hazard mapping and emergency response. A dataset of daily MODIS snow cover images for the period 2003 – 2010 was acquired for Lesotho. Combined with high-resolution SPOT satellite images for two study areas, MODIS snow cover images were used to establish the frequency, extent and timing of snowfalls. A digital elevation model was used in conjunction with mean air temperature data to investigate the effects of altitude, aspect and temperature on the mean rate of daily snowmelt. A strong correlation exists between mean day-time temperatures and the mean rate of daily snowmelt throughout the winter season. The mean rate of snow dissipation is most rapid after late season (September – November) snowfalls and least rapid after mid season (July – August) snowfalls. Snow cover persisting for 1 – 5 days dissipates at a higher mean rate than snow cover that has persisted for 6 – 10 days. Snow lasts longest on south-facing slopes above 2500m a.s.l, with evidence of increased ablation due to wind deflation and higher insolation levels in the highlands above 3400m a.s.l. The southern Drakensberg highlands in the district of Quthing have the highest mean duration of snow cover (21 – 25 days per annum). The seasonal extent and duration of snow cover was related to the spatial location of villages and roads in Lesotho, in order to determine individual vulnerability to negative impacts associated with prolonged snow cover. A ranking system was applied to each village according to the seasonal duration of snow cover, and the accessibility and proximity to the nearest road. Snowfalls occur between 1 and 8 times per annum on average. Therefore, village vulnerability is generally low, as most settlements are situated on predominantly north-facing slopes in the western lowlands and Senqu River Valley, which remain largely snow-free throughout the winter season. Few villages experience prolonged snow cover, which is limited to predominantly south-facing slopes above 2500m a.s.l along the escarpment and interior mountain ranges. Village vulnerability increases during the mid season period as a result of the increased frequency and duration of snow cover in July and August. The villages of Thoteng (Butha-Buthe), Letseng-la-Terae (Mokhotlong) and Mabalane (Butha-Buthe) have the highest vulnerability for the 2003 – 2010 period.

ACKNOWLEDGEMENTS

During a brief stay in Maseru, I received a digital village database from Mr. Lehlohonolo Moeti of the National University of Lesotho. The spatial analysis of village vulnerability conducted during this research would have been significantly less detailed and meaningful without these data, and I am very grateful to Mr. Moeti for his generous assistance. I would like to thank my supervisor, Prof. Stefan Grab for his encouragement, support, guidance and input during this project. Stefan constantly motivated and inspired me, especially during times where I had seemingly lost all direction. I am extremely grateful to Stefan for his assistance in revising countless drafts and chapters, and attempting to improve my academic writing abilities. Finally, I am eternally grateful to my mother and father for their unending emotional and financial support over the years.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS

a.s.l	Above Sea Level
DEM	Digital Elevation Model
ENSO	El Niño Southern Oscillation
ETM+	Enhanced Thematic Mapper
EWS	Early Warning System
GCM	General Circulation Model
GIS	Geographical Information System
GOL	Government of Lesotho
GPR	Ground Penetrating Radar
GPS	Geographic Positioning System
HIV/AIDS	Human Immuno-deficiency Virus/ Acquired Immuno-Deficiency Syndrome
LHWP	Lesotho Highlands Water Project
LMS	Lesotho Meteorological Services
MYA	Million Years Ago
NDSI	Normalized Difference Snow Index
RMS	Root Mean Square
SADC	Southern Africa Development Community
SCA	Snow Covered Area
SNOTEL	Snow Telemetry
SWE	Snow-Water Equivalent

1. INTRODUCTION

1.1 Background to study

Snow cover plays a critical role in the hydrological cycle, affecting many physical, chemical and biological processes (Haefner, *et al.,* 1997; de Ruyter de Wildt *et al.,* 2007; Liang *et al.,* 2008). In Alpine regions, snow has a pervasive influence on fauna, flora, hazards, and tourism activities (Evans *et al.,* 1989; Brander, *et al.,* 2000). Given its prevalence in high-latitude and high-altitude areas, snowfall represents a valuable resource in mountain environments, providing a considerable amount of downstream water supply as temperatures increase during summer (Haq, 2008). Snowmelt may contribute up to 80% of the annual discharge of some arctic streams and rivers, with many semi-arid and arid regions depending solely on snowmelt for the purposes of irrigation and power generation (Déry *et al.,* 2005). Whilst snow distribution is controlled by latitude and altitude (Jain *et al.,* 2009); aspect, slope gradient, topographic sheltering and vegetation influence the development of snow cover as well as the dynamics of snow cover dissipation (DeBeer and Pomeroy, 2009). Snow drifting and wind deflation are predominantly controlled by topography, along with localized weather and climatology (Evans *et al.,* 1989). The presence or absence of snow cover influences surface energy fluxes by affecting the albedo and temperature of the surface, with considerable climatological implications (DeBeer and Pomeroy, 2009). As snow cover fragments into patches with time, the areal extent of snowmelt is affected, altering the magnitude and rate of meltwater production (DeBeer and Pomeroy, 2009). Monitoring snow cover extent plays an essential role in preventing disasters in agricultural areas where snow accumulation may result in the death of animals and people, and the disruption of transport and telecommunications infrastructure (Liang *et al.,* 2008; Joyce *et al.,* 2009). Flooding may also occur where snow has melted abruptly, posing a threat to low-lying regions and communities (Oesch *et al.,* 2002; Haq, 2008).

Widespread, frequent snowfall is common at high latitudes and in Alpine environments, especially during winter in the Northern Hemisphere where snow cover persists year-round at high altitudes in some regions (Brown, 2000), including Alaska (Hall *et al.,* 1998), parts of the United States (Hiemstra *et al.,* 2002; Lundquist *et al.,* 2004; Shamir *et al.,* 2007), Canada (Brown and Braaten, 1997), the Arctic (Bruland, 2002), the European Alps (Beniston, 1997; Oesch *et al.,* 2002; Foppa *et al.,* 2007), the Spanish Pyrenees (Andrés, 2005; Esteban, 2005) and the Himalayas (Singh, 2003; Li and Williams, 2008; Jain *et al.,* 2009). However, seasonal snow cover also occurs at temperate latitudes with warmer climates, where snow distribution is predominantly controlled by altitude. Such regions include Turkey (Sorman *et al.,* 2007), Pakistan (Haq, 2008), the Atlas Mountains in Morocco (Chaponnière *et al.,* 2005; Boudhar *et al.,* 2009), the Andes (Vuille and Ammann, 1997; Hardy *et al.,* 1998; Albert, 2002) and the Australian Alps (Whetton *et al.,* 1996). In southern Africa, Lesotho receives winter snowfalls that frequently result in human and livestock fatalities (Tyson *et al.,* 1976; Tyson, 1986; Mulder and Grab, 2002, 2009; Nel and Sumner, 2008; Grab and Nash 2009). However, there is considerable lack of meteorological and precipitation data for Lesotho, especially with regard to human and livestock vulnerability to the negative impacts associated with prolonged snow cover.

Lesotho is a landlocked country, completely surrounded by South Africa. The Drakensberg escarpment flanks the eastern border, whilst the plains of the eastern Free State in South Africa meet the western lowlands of Lesotho along the Caledon River. Lesotho contains some of the highest mountains in southern Africa, and the highlands account for 80% of the total land area of the country (Schmitz and Rooyani, 1987). The Maluti Mountains form a distinct range and separate the northwestern highlands from the lowlands, whilst two smaller ranges occupy the interior, the Central Range and Thaba Putsoa Range. The climate of Lesotho is seasonal, and is strongly influenced by maritime air circulating in from the Indian Ocean (van Zinderen Bakker and Werger, 1974). Snowfall is often experienced along the Drakensberg and in Lesotho during winter months (Tyson, 1986; Mulder and Grab, 2002, 2009; Nel and Sumner, 2008), although rare localized snowfalls have been known to occur during summer (Boelhouwers and Meiklejohn, 2002; Grab and Nash, 2009). Light snowfalls occur between two and ten times annually (Tyson *et al*., 1976; Sene *et al*., 1998), yet infrequent heavier snowfalls have been recorded, often leaving snow accumulations of over 50cm and high-mountain communities snowbound for several weeks during winter (Grab, 2005; Mulder and Grab, 2009). Snow may remain on the ground for several months during winter, mainly above 3000m a.s.l on south-facing slopes (Tyson *et al.*, 1976; Sene *et al.,* 1998; Boelhouwers and Meiklejohn, 2002; Mulder and Grab, 2002; Mokotjomela *et* al., 2009). Cut-off lows are responsible for about 15% of snow over the Drakensberg in general, but areas along the escarpment north of Giant's Castle are more likely to experience snowfall from cut-off lows (Mulder and Grab, 2009). About 10% of snowfall is caused by offshore low-pressure systems along the eastern coast of southern Africa during late winter or early spring (Mulder and Grab, 2009). Historical and contemporary accounts of severe snow in Lesotho recorded human deaths, heavy livestock losses and damage to fruit trees (Grab and Nash, 2010). However, Lesotho has faced considerable climate variability in the past, experiencing frequent severe cold seasons as well as extended periods of drought since the early 19^{th} century (Nash and Grab, 2010).

Rainfall data for the high Drakensberg are generally lacking, with weather stations mostly confined to altitudes of below 1800m a.s.l. (Sumner and Nel, 2006). Rain is produced by large-scale line thunderstorms and orographically induced storms (Tyson et al., 1976). The variability of summer rainfall in the region is strongly influenced by the El Niño/Southern Oscillation (ENSO) effect (Nel and Sumner, 2008). Hail is frequent in small patches following thunderstorms, and may last for several days in shaded areas (Guillarmod, 1968) or on high peaks (Killick, 1963). Whilst there are few mean annual temperature data for the Drakensberg, the region has the highest frequency of below-freezing temperatures and 'cold snaps' in South Africa (Tyson, 1988). Many areas in the highlands experience ground frost on approximately 200 days per year, and significant diurnal changes in temperature result in the formation of frost-related phenomena including needle ice, patterned ground, solifluction, and thufa in the highlands (van Zinderen Bakker and Werger, 1974; Sene *et al.,* 1998; Grab, 1998).

Whilst Lesotho has faced immense development challenges for several decades (Wallman, 1972), the country is now suffering severe land degradation and soil erosion as a result of increasing pressure from the growing population (Rydgren, 1988; Showers and Malahleha, 1992; Obioha, 2010). It has been established that Lesotho lacks adequate infrastructure for industrial and commercial enterprises outside of urban centres, which is largely attributed to the shortage of technically trained professionals, the large gap between supply and demand of basic services, and a lack of investment in infrastructure projects (Government of Lesotho, 2005). The country compares poorly with other Southern African Development Community (SADC) states in terms of technology infrastructure including transport networks, cargo port infrastructure, and energy and communication networks (Government of Lesotho, 2005). Infrastructure service delivery in Lesotho is below the expected level for a country in Lesotho's income group, although Lesotho has exhibited progress with regard to provision of water and basic sanitation (Bogetic, 2006). Failure to provide access to affordable or adequate infrastructure services to low-income groups is often associated with negative social impacts (Lawson, 2008). Individuals living furthest from public transport facilities and water sources tend to be among the poorest in Lesotho (Lawson, 2008). However, despite the relatively sparse network of transport routes in Lesotho, participatory planning methods are being integrated with Geographical Information Systems (GIS) to prioritize road maintenance and devise alternate routes in remote mountain regions (Vajjhala and Walker, 2009).

Food insecurity also remains a persistent challenge to most of southern Africa (FFSSA, 2004; Bryceson and Fonseca, 2006; Romero-Daza *et al.,* 2009), mainly due to unfavorable and unpredictable climatic conditions (Eckert, 1983). In addition, Lesotho is experiencing a severe HIV/AIDS epidemic, with high prevalence among young women and men (Gouws *et al.,* 2008). The high prevalence of HIV has eroded traditional coping mechanisms and social networks, and is compounded by poorly funded and mismanaged government prevention strategies (Nyabanyaba, 2008; Piot *et al.*, 2008). Therefore, individual vulnerability to biophysical threats and socioeconomic risks is increasingly high in Lesotho, given the current economic and political climate, and worsening environmental conditions.

1.2 Snow cover mapping

Snow affects moisture and energy exchanges between the atmosphere and the surface, and has an important role in the Earth's radiation balance as it has the highest albedo of any natural and spatially extensive surface. Additionally, the presence or absence of snow cover is an important indicator of climate change (Haefner, *et al.,* 1997; Bavay *et al.,* 2009), which acts as a control on the soil thermal regime and atmospheric exchange of greenhouse gases (Dankers and De Jong, 2004), and has a pervasive influence on fauna, flora, hazards and economic activities (Brander *et al*., 2000; Jonas *et al.,* 2008a, 2008b; Bebi *et al.,* 2009). Accurate snow mapping and modeling of snowmelt/runoff is thus a critical first step in the mitigation of snow disasters and associated economic losses.

There has been growing interest in the spatio-temporal patterns of snow cover (Mulder and Grab, 2002; Mulder, 2007; Mulder and Grab, 2009) and its associations with cold region landform distribution in Lesotho and the high Drakensberg (Grab *et al.,* 2009). However, the mountainous terrain limits the potential for extensive groundtruthing in the region, especially in the eastern Highlands. Therefore, satellites are ideal platforms for remote sensing of snow cover due to their high spatial and spectral resolution, and the ability to map large regions of the Earth at regular time intervals (de Ruyter de Wildt *et al.,* 2007). The synoptic view and repetitive coverage of satellite imagery is an effective means of mapping the surface characteristics and dynamics of inhospitable or inaccessible areas (Gao and Liu, 2001). With growing interest in the effects of climate change on snow dynamics, Moderate Resolution Imaging Spectroradiometer (MODIS) multi-temporal imagery is a valuable product when calculating interannual variability of snowfall in alpine regions (Reed *et al.,* 2009). The MODIS instrument possessed considerable advantages over similar operational snow mapping platforms due to its 250m spatial resolution and global coverage (Hall *et al.,* 2002).

The MODIS instrument can distinguish snow independent of cloud cover and complex topography, providing superior snow cover area (SCA) estimations to those from other operational platforms such as AVHRR and GOES satellites (Hall *et al.,* 2001; Maurer *et* *al.,* 2003). The MODIS snow product classification is based on the normalized difference snow index (NDSI) (Riggs *et al.,* 2006), which distinguishes between snow and clouds or other non-snow surfaces, due to the high reflectance of snow in visible wavelengths and low reflectance in the shortwave infrared wavelengths (Klein *et al.,* 1998; Salomonson and Appel, 2004). MODIS snow cover mapping is facilitated by means of the SNOMAP threshold (Hall *et al.,* 1995). Although Landsat imagery has higher spatial resolution than MODIS (30m pixel size), it only has seven spectral bands, and a repeat overpass of 16 days (Dozier, 1989). The resolution of SPOT imagery (10m and 20m pixel size) is also higher than MODIS, but has poorer spectral and temporal coverage than either Landsat or MODIS (Gao and Liu, 2001). Therefore, snow cover persisting for shorter periods may be missed entirely by Landsat or SPOT sensors.

The MODIS Rapid Response System provides regular imagery of selected areas of the Earth's surface and was developed to meet the near real time needs of the applications community (Pinheiro *et al.,* 2007; Haq, 2008). Rapid Response imagery has diverse applications in land cover mapping as a result of its near-real time acquisition and is increasingly used in the analysis of seasonal snow cover trends (Haq, 2008; Joyce *et al.,* 2009). With many of its products available online within hours of satellite overpass, the global dataset is automatically updated on a daily basis, making it a valuable source of spatial information for a variety of applications. The MODIS Rapid Response System's flexibility in terms of data products, subsets, projections and formats allows high-volume users to access custom land-cover products that are not available through standard MODIS processing (Pinheiro *et al.,* 2007).

1.3 Snow and vulnerability

Heavy snowfalls are often associated with the onset of extremely cold conditions and can pose a significant threat to humans, livestock and property (Kääb, 2002; Prior and Kendon, 2011). Urban areas are particularly susceptible to the disruptions of snowstorms (Rooney, 1967) as roofs and electrical power lines collapse under the weight of snow, roads become blocked, and people may remain isolated for long periods (Pinto *et al.,* 2007). Mountain regions prone to frequent, heavy snowfalls are particularly susceptible to associated hazards, such as ice avalanches, collapse of infrastructure, and restriction of movement. The magnitude of avalanche disasters is rapidly increasing as urban growth extends into hazard zones (Sharma and Ganju, 2000). The exploitation of land for habitation and agricultural purposes within known avalanche tracks has led to increased fatalities and damage to infrastructure in mountainous regions (Richardson and Reynolds, 2000; Oberoi and Thakur, 2005).

Heavy snowfalls resulting in prolonged snow cover occur frequently in mountainous regions in Asia, Europe, North America and South America. However, heavy, widespread snowfalls occur relatively infrequently in Lesotho, therefore snow cover mapping has largely been overlooked for the region. Documentary evidence of snow cover records and climate variability has been explored for Lesotho for the period 1833 – 1900, indicating that severe to very severe cold seasons have occurred in the past, and were accompanied by freezing temperatures and frost (Grab and Nash, 2010).

1.4 Motivation

Lesotho occupies a considerable areal extent, which is under significant pressure by its growing population of 2.2 million people requiring tenure and the means to establish sustainable livelihoods (Obioha, 2010). Consequently, the Government of Lesotho faces the task of upgrading infrastructure and increasing the accessibility of basic services to citizens. The country has increasingly high rates of HIV/AIDS prevalence, which compounds the socioeconomic challenges already facing residents. Further, considerable climate and rainfall variability decreases the ability of subsistence farmers to maintain food security, and increases Lesotho’s reliance on food exports from South Africa (Ziervogel *et al.,* 2006). Given that snowfalls frequently affect the majority of communities in Lesotho, it is evident that the country is vulnerable to a myriad of biophysical and socioeconomic hazards. However, there is a lack of quantitative information on the frequency and seasonal variability of snowfall and snow duration across spatial scales in Lesotho.

There is a paucity of meteorological, social, and physical data for Lesotho. Whilst the Lesotho Meteorological Services (LMS) collects daily weather data, these are lacking spatially and temporally due to the considerably heterogeneous topography of Lesotho. Past research has focused on the adjoining Drakensberg escarpment and limited regions of the Lesotho highlands, which are more accessible from South Africa. Most of this work focused on reconstructing the Quaternary environment of the Drakensberg, with a particular focus on periglacial and glacial geomorphology (Grab, 1999; Boelhouwers and Meiklejohn, 2002). Consequently, literature over the last decade has centred on landforms associated with high altitude slope processes such as periglacial slope accumulations and relict periglacial landforms (Grab, 1999, 2002a, 2002b, 2005; Boelhouwers *et al.,* 2002; Sumner, 2003; Grab and Mills, 2011). From a geomorphological perspective, the occurrence of snowfall in the Drakensberg has received superficial attention, although recently there has been growing interest in the spatio-temporal patterns of snow cover (Mulder and Grab, 2002, 2009; Mulder, 2007) and its associations with cold region landform distribution (Grab *et al.,* 2009). Any new data on snow frequency, duration and distribution should thus benefit geomorphological and biophysical studies which include snow as an environmental variable.

Previously, snow mapping in Lesotho on a countrywide scale has been limited by technology and the cost and accessibility of satellite imagery. However, MODIS Rapid Response images may be obtained from the Internet at minimal cost. Further, the MODIS online database consists of daily imagery from several years, which enables the mapping of snow cover at increasingly high temporal scales. MODIS Rapid Response imagery is available with 250m spatial resolution, which is ideal for snow cover mapping at countrywide scales. Increasingly, high-resolution DEMs are more accessible, and facilitate the investigation of topographic controls on snow cover extent and duration. The combination of DEMs and satellite imagery is especially useful for mountainous regions with diverse topographic regimes such as Lesotho. GIS software enables users to create and access databases, compare data statistically and spatially, and visualize the resulting products and images (Karimi and Houston, 1997). GIS tools are commonly used in conjunction with digital elevation models (DEMs), digital topographical maps and remote-sensing data for mapping (Mulders, 2001). Coupled with decreasing software costs, the utility of GIS for hazard mapping and disaster management is increasing (Zerger and Smith, 2003). Because hazards are multi-dimensional issues that have spatial components, GIS is a well-suited tool for delineating hazard boundaries and other characteristics (Zerger, 2002). By integrating village data with satellite imagery and a DEM using GIS, the relationships between snowfall frequency, snow duration and melt, and village vulnerability in Lesotho, can be explored at relatively high temporal and spatial scales.

1.5 Aims and objectives

The primary objective of this paper is to provide an indication of areas most vulnerable to frequent snowfalls and longest-lasting snow cover. Particular aims are to investigate the duration and extent of snow cover in Lesotho for different topographical settings by using multi-temporal MODIS and SPOT satellite imagery as well as a DEM. Seasonal trends in snowfall and snowmelt are explored using daily MODIS satellite images for an 8-year period (2003 – 2010). The vulnerability of 2016 villages in Lesotho is assessed based on the duration of snow cover, proximity to roads and the accessibility of roads for the purpose of investigating vulnerability to the negative impacts of prolonged snow cover. The distribution and ablation of snow cover is analyzed according to the seasonal timing of snowfalls; and overall vulnerability is expressed according to the incidence of early, mid or late season snowfalls. Ultimately, the objective is to assess the snow hazard, determine the vulnerability of villages to prolonged snow cover, and increase the efficiency of evacuation or relief in the event of severe snowfalls. The construction and presentation of such seasonal vulnerability maps may also assist in mitigating against human and livestock deaths as a result of prolonged snowfall.

1.5.1 Hypotheses

Through the course of this research, the following hypotheses will be tested for Lesotho:

i. Using multi-temporal and multi-resolution satellite images of Lesotho for an 8-year period, it is argued that:

- the majority of snowfalls occur during the mid season period (July and August);
- snow cover persists longest after mid season snowfalls than after early or late season snowfalls;
- snow cover will persist longest at high altitudes and on south-facing slopes;
- the eastern Lesotho Highlands and Drakensberg escarpment experience heavier and more frequent snowfalls than the central Lesotho ranges.

ii. By comparing mean daily rates of snowmelt with air temperatures and topography, it is proposed that:

- the mean rate of daily snowmelt is greatest at lower altitudes and on north-facing slopes;
- the mean rate of daily snowmelt is controlled by mean day-time and nocturnal temperatures;
- the mean rate of daily snowmelt fluctuates with the seasonal timing of snowfalls.

iii. Comparing the duration, extent and seasonal timing of snowfalls, it is hypothesized that:

- the vulnerability of villages is strongly affected by the seasonal timing of snowfalls;
- villages at higher altitudes are more vulnerable to prolonged snow cover;
- villages in the Lesotho highlands and interior mountain ranges are more vulnerable to prolonged snow cover than those in the western lowlands and Senqu River Valley.

2. ENVIRONMENTAL SETTING

2.1 Regional setting

Lesotho is situated between longitudes 27°00’E and 29°30’E and latitudes 28°30’S and 30°40’S, and is completely surounded by South Africa (Rydgren, 1988) (Figure 2.1). The country covers 30,355km^2 and consists of four main physiographic zones: the western lowlands, the foothills, Senqu River Valley and the central and eastern highlands (Schmitz and Rooyani, 1987) (Figure 2.2). The highlands account for 80% of the total land area of Lesotho, and contain some of the highest mountains in southern Africa (King, 1942), ranging from 1400m a.s.l to an altitude of 3482m a.s.l at Thabana Ntlenyana (29°30’S, 29°30’E) (Boelhouwers and Meiklejohn, 2002; Nel and Sumner, 2008; Grab et al., 2009). The Maluti Mountains form a distinct range and separate the northwestern highlands from the lowlands (Figure 2.1) (King, 1942). Two smaller ranges occupy the interior, the Central Range and Thaba Putsoa Range. The Drakensberg forms part of the southern African Great Escarpment and flanks the entire eastern side of Lesotho between latitude 28° 30’S - 30° 30’S and longitude 28° 30’E - 29° 30’E (Tyson *et al.,* 1976). Together with the adjoining Lesotho highlands, the Drakensberg forms a watershed that divides runoff between the Tugela River to the east and the Senqu/Orange River system to the west. This watershed remains above 2820m a.s.l from the Amphitheatre (28°30’S; 28°45’E) to the Leqooa Valley (29°45’S; 29°12’E) (Grab *et al.,* 2009). The Drakensberg received World Heritage Site status in 2000 (Shroyer and Blignaut, 2003) and was recently declared a Trans-Frontier National Park (Nel, 2008). The foothills contain many historically and culturally valuable San rock-painting sites in numerous sandstone caves that are common below 2600m a.s.l (Moore and Blenkinskop, 2006; Sumner and Nel, 2006). The combination of unique flora (Killick, 1990) and fauna, impressive scenery and historical significance makes the region an increasingly popular travel destination for international and domestic tourists alike (Linde and Grab, 2008; Nel and Sumner, 2008).

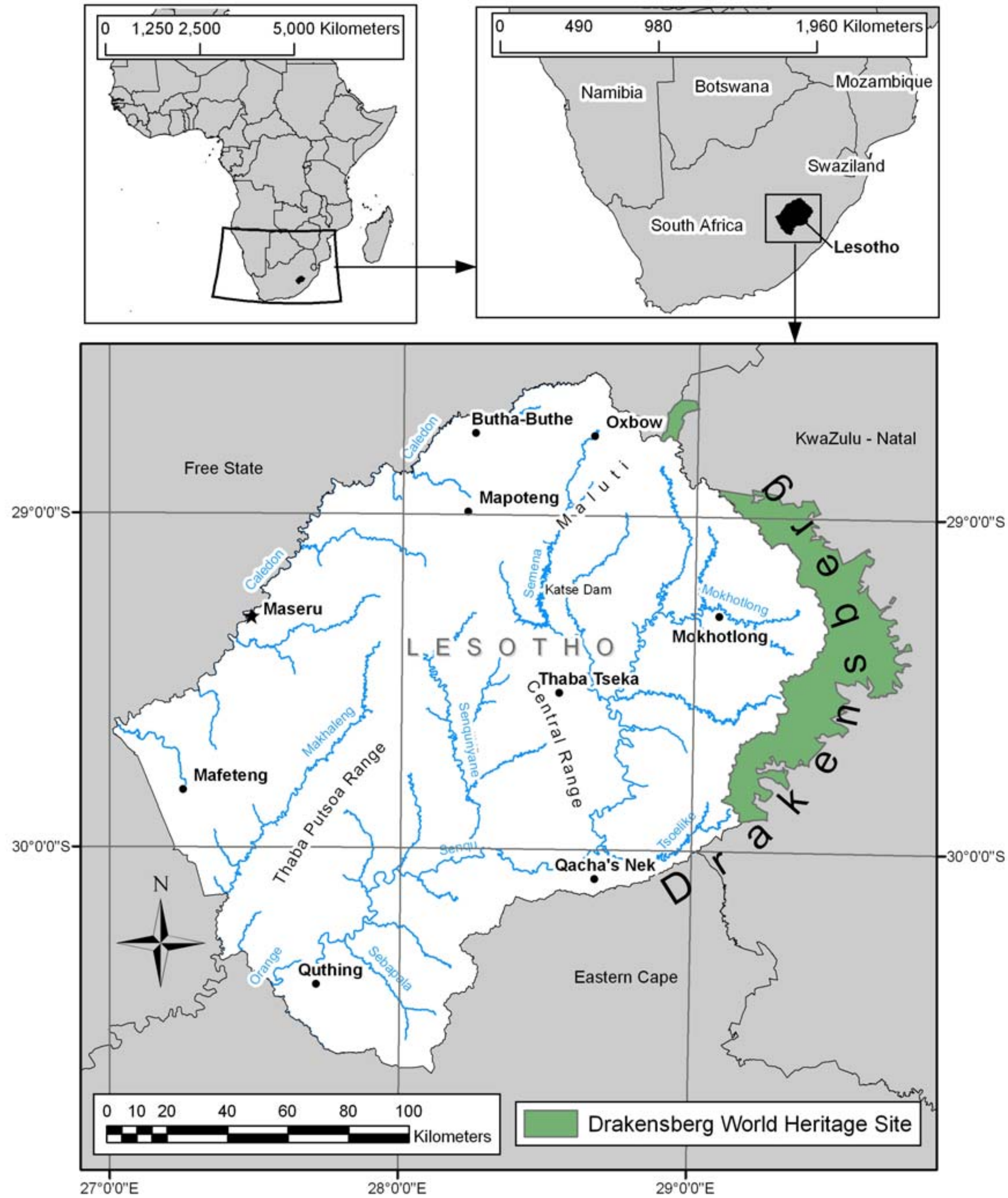

Figure 2.1: The position of Lesotho in southern Africa.

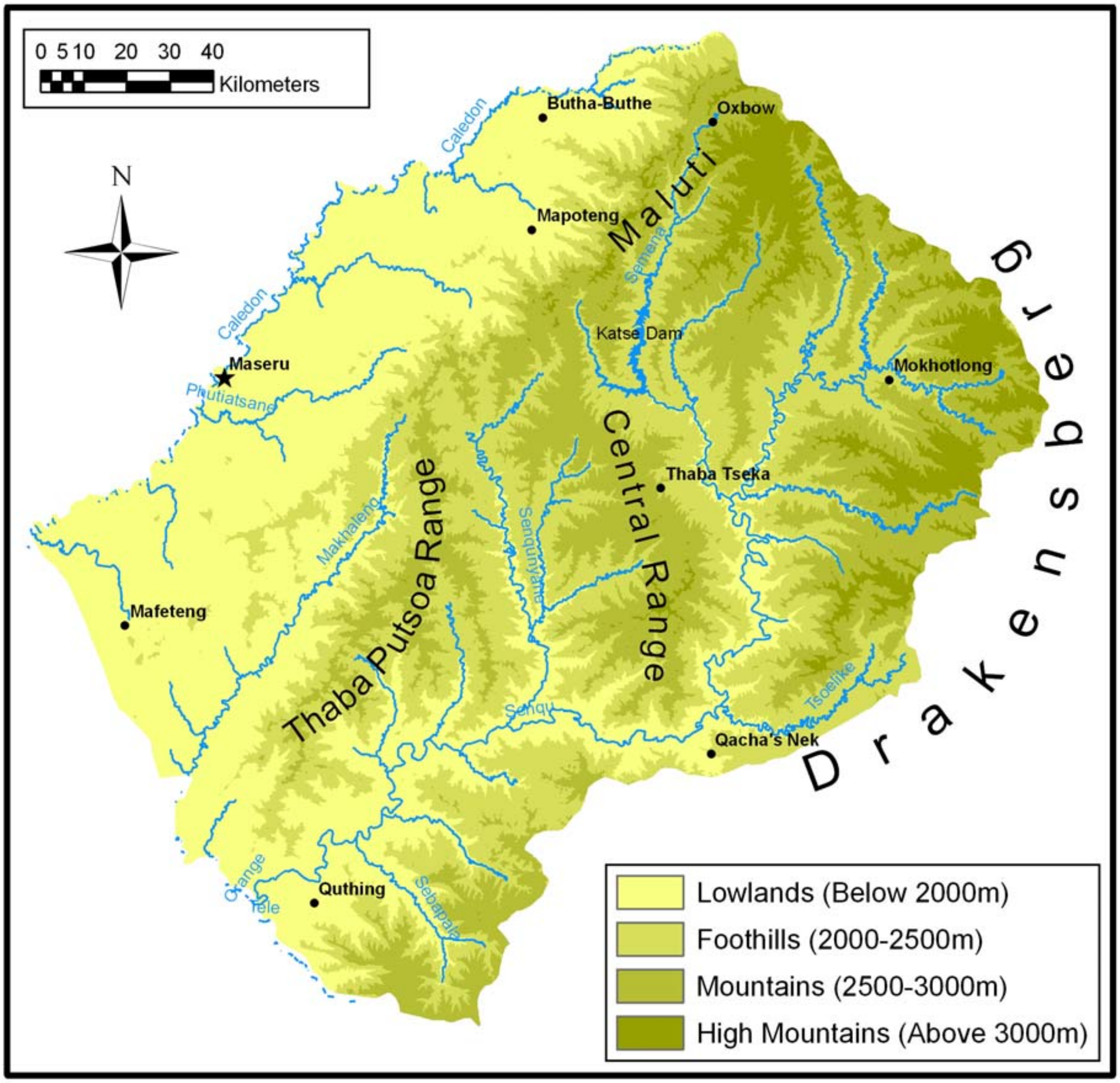

Figure 2.2: The main physiographic regions and mountain ranges in Lesotho (DWAF, 2010; CSIR, 2010).

2.2 Climate

2.2.1 The Drakensberg escarpment

The weather and climate of the Drakensberg is affected by incumbent circulation systems in both the tropics to the north and temperate latitudes to the south, due to its location in subtropical southern Africa (Preston-Whyte and Tyson, 1988) (Figure 2.3). South Africa itself is bisected by the mean position of the subtropical high-pressure belt at about 30°S

(Tyson *et al*., 1976). During the southern hemisphere summer, this high-pressure band weakens and moves southward, whilst in winter it intensifies and shifts northward. As mean pressure decreases over the southern African interior during summer, maritime air is advected from the Indian Ocean and circulates over the eastern half of South Africa, whilst the western parts of the country experience northerly flow of moist air from the tropics (Tyson *et al*., 1976; Preston-Whyte and Tyson, 1988). The onset of the winter circulation pattern is accompanied by the significant westward migration of the South Indian Ocean high-pressure cell, which extends toward the western half of the Indian Ocean (Preston-Whyte and Tyson, 1988). The presence of this high-pressure cell off the east coast of southern Africa has a profound effect on the winter climate over the region (Tyson *et al*., 1976). The northward shift of the subtropical high-pressure belt causes South Africa to be affected by disturbances in the westerly waves, trailing cold fronts across the southern part of South Africa (Preston-Whyte and Tyson, 1988). The Drakensberg escarpment commonly experiences winter cold frontal systems (Mulder, 2007) which are the result of mid-latitude cyclones moving in a west-northwest to east-southeast direction over the South Atlantic Ocean, mainly due to the blocking effect of a high-pressure cell over the subcontinent (Tyson *et al.,* 1976) (Figure 2.3).

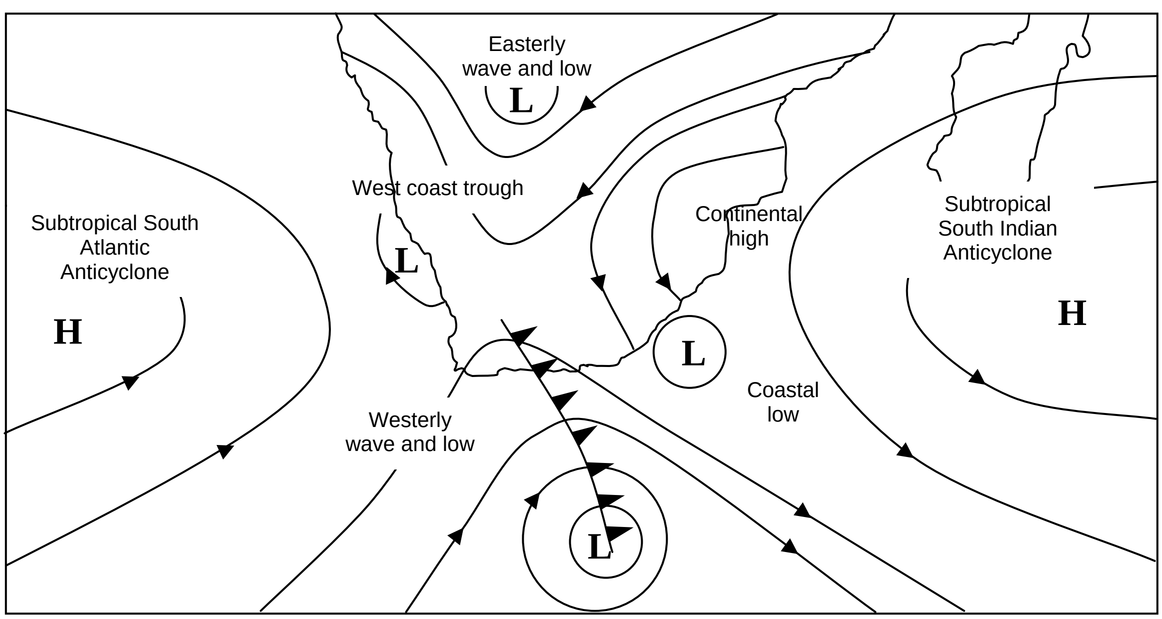

Figure 2.3: Surface air features over southern Africa (after Preston-Whyte and Tyson, 1988).

Precipitation in the Drakensberg is strongly seasonal, with more than 80% of the mean annual total falling in the summer months between October and March where mid- to late-afternoon thunderstorms are experienced on approximately 100 days *per annum* (Tyson *et al*., 1976). There are two main rain-producing systems in the Drakensberg: large-scale line thunderstorms and orographically induced storms (Tyson *et al.,* 1976). The variability of summer rainfall in the region is strongly influenced by the El Niño/Southern Oscillation (ENSO) effect (Nel and Sumner, 2008). However, the amount and duration of rainfall is higher in the foothills than on the escarpment (Nel *et al.,* 2010). The seaward-facing scarp of the lower Drakensberg receives over 1600mm in mean annual rainfall in places, where light rain and drizzle may occur during any season (Sene *et al.,* 1998; Hydén, 2002). In the higher foothills of the little Berg, a mean annual rainfall of 1176mm and 1311mm was recorded for the southern and northern Drakensberg respectively for the years 1970 to 2002 (Nel and Sumner, 2005). However, rainfall data for the high Drakensberg are generally lacking, with weather stations mostly confined to altitudes of below 1800m a.s.l. (Sumner and Nel, 2006). Despite limited records, a mean annual rainfall of 742mm for Sani Pass Top (1970 to 2002) and 765mm for Sentinel Peak (2002) were recorded at high Drakensberg sites (Nel and Sumner, 2005). Whilst snowfall may account for an estimated 10% of precipitation, the proportions of other forms of precipitation remain unknown (Nel *et al.,* 2010). Hail regularly occurs during thunderstorms, and may last for several days in shaded areas (Guillarmod, 1968) or on high peaks (Killick, 1963).

Whilst there are few mean annual temperature data for the Drakensberg, the region has the highest frequency of below-freezing temperatures and 'cold snaps' in South Africa (Tyson, 1988). The mean winter temperature for the high Drakensberg is 5°C, but daily temperatures regularly drop below 0°C and snow may remain on the ground for several months during winter, mainly above 3000m a.s.l on south-facing slopes (Tyson *et al*., 1976; Sene *et al.,* 1998; Boelhouwers and Meiklejohn, 2002; Mulder and Grab, 2002, 2009; Mokotjomela *et* al., 2009). Seasonal freezing of the ground is common (Boelhouwers and Meiklejohn, 2002; Nel and Sumner, 2008), often to a depth of > 50cm as a result of nocturnal cooling (Grab, 2002a). The lower Drakensberg experiences mild, wet summers with an average temperature of 17°C (Tyson *et al.,* 1976). Above 2600m a.s.l the environmental lapse rate is between 2.6°C/km and 3°C/km (Nel and Sumner, 2008). During the wet summer months, average daily sunshine in the Drakensberg is 5.5 hours, or 39% of the possible sunshine (Killick, 1963). However, Drakensberg winters are generally cloud-free and thus receive up to 80% of possible winter sunshine; mean annual total radiation for the area is 190×10^5 Jm^{-2} day^{-1} (Tyson *et al.,* 1976).

Snowfall is often experienced along the Drakensberg during winter months (Tyson, 1986; Mulder and Grab, 2002; Nel and Sumner, 2008), although rare localized snowfalls have been known to occur during summer (Boelhouwers and Meiklejohn, 2002; Grab and Nash, 2009). Light snowfalls occur between two and ten times annually (Tyson *et al*., 1976; Sene *et al*., 1998). However, infrequent heavier snowfalls have been recorded, often leaving snow accumulations of over 50cm and high-mountain communities snowbound for several weeks during winter (Grab, 2005; Mulder and Grab, 2009). During the particularly cold winter of 1957, snow remained on the summit of the escarpment for two months (Killick, 1963). Snowfall increases the soil moisture content during winter, and acts as an insulating layer, preventing underlying soil from freezing (Killick, 1963). Cold fronts and associated cut-off lows account for 80% of snowfalls over the Drakensberg and result in relatively uniform spatial coverage, but extensive snow accumulation is limited to altitudes of above 3000m a.s.l (Mulder and Grab, 2009). Cut-off lows are responsible for about 15% of snow over the Drakensberg in general, but areas along the escarpment north of Giant's Castle are more likely to experience snowfall from cut-off lows (Mulder and Grab, 2009). About 10% of snowfall is caused by offshore low-pressure systems along the eastern coast of southern Africa during late winter or early spring (Mulder and Grab, 2009).

2.2.2 Lesotho

The climate of Lesotho is seasonal, and is strongly influenced by maritime air circulating in from the Indian Ocean (van Zinderen Bakker and Werger, 1974). Lesotho receives over 80% of its annual rainfall in the form of intense thunderstorms during the months of October to March (Chakela, 1980; Sene *et al.,* 1998). Mean annual rainfall ranges from

650mm in the lowlands to over 1600mm in the highlands, with the northwest face of the Malutis receiving especially high rainfall (van Zinderen Bakker and Werger, 1974; Chakela, 1980; Chakela and Stocking, 1988). However, Lesotho experiences high inter-annual rainfall variability (Hydén, 2002). Prolonged drought conditions are associated with the El Niño phenomenon and result in famine, critical food shortages, disease epidemics, dust bowls and invasion by destructive exotic plant and insect species, whilst 'wet spells' related to La Niña events sometimes cause flooding (Government of Lesotho, 1997).

Based on documentary evidence from 1833-1900, Lesotho has experienced severe cold seasons after major southern hemisphere and tropical volcanic eruptions (Grab and Nash, 2010). Heavy and frequent snowfalls and early frosts are associated with such events. The temperate, semi-arid western lowlands (1400-1850m a.s.l) experience mean annual temperatures of 14-17°C whilst the average daily temperature at high elevations (>2500m a.s.l) is 16°C, with minimum annual average temperatures of 6°C (van Zinderen Bakker and Werger, 1974; Rydgren, 1988). In the past, minimum nocturnal temperatures at soil level could fall below 0°C at any time of the year (van Zinderen Bakker and Werger, 1974). Many areas in the highlands experience ground frost on approximately 200 days per year, and significant diurnal changes in temperature result in the formation of frost-related phenomena including needle ice, needle ice mounds, patterned ground, stone-banked lobes, and earth hummocks (thufa) in the highlands (van Zinderen Bakker and Werger, 1974; Grab, 1998, 2000, 2002, 2005).

2.3 Vegetation

As a result of its high relief and diverse climatic and topographic regimes, the Drakensberg contains a broad range of habitats and unique plant communities (Killick, 1990). A large number of wetlands have formed at a range of altitudes, further contributing to the biodiversity of vegetation in the region (Sieben *et al.,* 2010). The Drakensberg Alpine Centre (DAC) with its high levels of endemism comprises the foothills, mountains and plateau along the full extent of the escarpment, and supports over 2800 specific and infraspecific taxa with 16% of the angiosperm taxa being endemic to the region (Carbutt and Edwards, 2003). The majority of endemic and near-endemic angiosperm families in the DAC are Asterceae, Scrophulariaceae and Iridaceae, whilst *Helichrysum* and *Senecio* contribute the most endemic and near-endemic angiosperm species (Carbutt and Edwards, 2006). In the KwaZulu-Natal Drakensberg there are three climax communities, therefore the vegetation is classified according to three altitudinal zones: the montane belt (1280 – 1829m a.s.l), subalpine belt (1829 – 2865m a.s.l) and the alpine belt (2865 – ±3353m a.s.l) (Killick, 1963). These vegetation belts correspond with the three main terraces of the Drakensberg, the river valley system, the Little Berg and the summit area (Figure 2.4). The montane belt extends from the valley floors to the lower edge of the Little Berg, and is characterized by *Podocarpus latifolius* (Real Yellowwood) forest as the climax community (Killick, 1963; 1990). However, this vegetation belt is also inhabited by *Themeda*, *Hyparrhenia*, *Miscanthus* and *Cymbopogon* grasslands, along with bracken veld, scrub, and *Protea* savanna. The subalpine belt ranges from the edge of the Little Berg to just below the summit of the Drakensberg, and has *Passerina, Philippia* and *Widdringtonia* fynbos as climax communities. Subalpine vegetation is characterized mainly by temperate grassland, but includes bracken veld, *Protea* savanna, streambank communities, outcrop vegetation and subalpine fynbos (Schmitz and Rooyani, 1987). The alpine belt is a homogenous zone of vegetation extending along the entire summit of the Drakensberg, and is characterized by *Erica* and *Helichrysum* heath as climax communities (Killick, 1963). The alpine vegetation belt also contains several aquatic and hygrophilous species that inhabit bogs, streams and wet soil on the summit (Killick, 1990). C_3 and C_4 grasses and sedges are common inhabitants of wetlands at all altitudes in the Drakensberg (Sieben *et al.,* 2010).

The vegetation of Lesotho is predominantly grassland, with shrubs occurring at higher elevations (Schmitz and Rooyani, 1987). Indigenous trees such as Cape willows, *cheche* bush, aloes and wild olives are also common (Obioha, 2010). The flora of the ‘Afroalpine region’ stretches across Lesotho to within 50km of the western border (Hilliard and Burtt, 1987). The lowland ecological zone (1500-1800m a.s.l) and the Senqu River Valley zone (1500-2000m a.s.l) are dominated by *Cymbopogen-Themeda* sourveld (Seboku sourveld), whilst the upper foothills and mountain valleys (1800-2500m a.s.l) are dominated by mixed sourveld of *Themeda Triandra* and *Festuca Caprina* (Schmitz and Rooyani, 1987). The subalpine zone (2300-2900m a.s.l) has climax communities of *Passerina-Philippia-Widringtonia* fynbos dominated by *Themeda Triandra* species, whilst the alpine vegetation belt (2900-3500m a.s.l) has a climax community of *Erica* and *Helichrysum* heath with *Festuca*, *Danthonia*, and *Pentaschistis* grassland (van Zinderen Bakker and Werger, 1974).

2.4 Geology and geomorphology

The continent of Africa formed part of the larger landmass of Gondwanaland during the late Palaeozoic and early Mesozoic eras (Dingle *et al.,* 1983). Southeast Africa began to split from Antarctica approximately 132 MYA, which, accompanied by seafloor spreading, signaled the breaking apart of Gondwanaland (Schmitz and Rooyani, 1987). The second major dismemberment was the separation of Africa and South America, which began about 126 MYA. In the final phase, the African landmass was uplifted, exposing 'new' African coastlines that reoriented drainage and deposition from interior basins to the new coastal margins. Cratonisation of the African continent was fully developed by the Paleozoic era (Truswell, 1977).

One of the cratons formed during this period, the Kaapvaal Craton, currently underlies northern Lesotho. The rock sequences of this craton form a complex schist belt of folded, and subsequently eroded, sedimentary and volcanic layers that underwent intrusion by basic rocks and granites (Schmitz and Rooyani, 1987). The Kaapvaal Craton also underwent intrusions of diamondiferous kimberlite, which occur in the Lesotho landscape as clusters along a northwest – southeast axis. Lesotho is located in the eastern region of the Karroo Basin, where most of the original sedimentary material has been stripped by erosion revealing older geological sequences of the Stormberg and Beaufort Groups (Truswell, 1977).

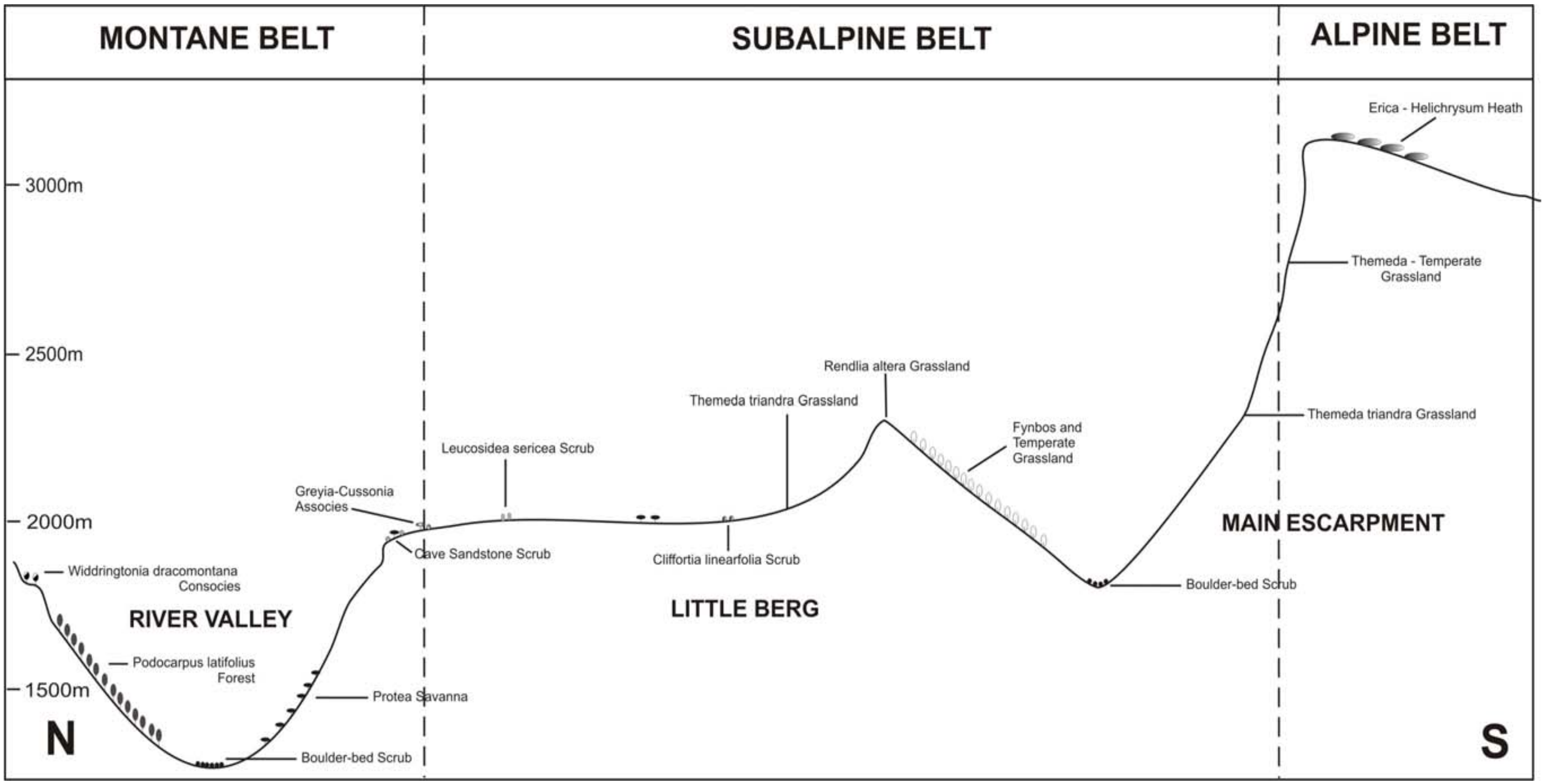

Figure 2.4: Profile through the Drakensberg area showing the vegetation belts with their chief plant communities (after Killick, 1963).

During the early Jurassic, as the Clarens Formation reached the final stages of deposition, a considerable number of widespread and discrete volcanic centres produced ejecta that became deposited as volcanic ashes, tuffs and agglomerates over Lesotho (King, 1942; Dingle *et al.,* 1983). Beds of volcanic tuff and agglomerate are found in southern Lesotho, between Clarens sandstones and basaltic lavas (Schmitz and Rooyani, 1987). Following this explosive phase, intruding magma spread over the sediments of the Karoo Basin in successive fissure flows, building up a 1600m thick sequence of amygdaloidal basalt layers (King, 1942) forming the Lesotho Formation (Schmitz and Rooyani, 1987). This formation initially extended beyond the borders of Lesotho, but a considerable thickness of the sequence has been removed by subsequent erosion (King, 1942). Once volcanic activity ceased, a widespread lava plateau remained of little relief, leaving a dense network of dykes, sills and pipes that characterize the present Lesotho Formation (Dingle *et al.,* 1983; Schmitz and Rooyani, 1987).

Presently, 70% of the surface of Lesotho is composed of outcroppings of basaltic lavas that form the mountain area and upper foothills (Schmitz and Rooyani, 1987). Dolerite dykes and sills have been exposed by erosion and occur throughout the country in mainly NW – SE and NE – SW orientations (Schmitz and Rooyani, 1987). Clusters of kimberlite pipes occurring in northern Lesotho have been the centre of diamond mining operations, and although uranium deposits exist, the limited dimensions of uranium occurrences make exploration unfeasible (Schmitz and Rooyani, 1987). Although occasional minor earthquakes occur in Lesotho, seismicity is weak and the distribution of seismic activity shows no correlation to surface features or geology (Truswell, 1977; Schmitz and Rooyani, 1987).

2.4.1 Geomorphological evolution

After the last basalts of the Lesotho Formation were laid down approximately 155 MYA, Lesotho consisted of an extensive lava plateau with relatively little relief. Subsequently, Gondwanaland fragmented in the early Cretaceous, with differential crustal warping and uplift occurring since the middle Cretaceous (Schmitz and Rooyani, 1987; Partridge, 1998). The further geological history has been dominated by the formation of planation surfaces and a shift from interior to coastal drainage (Table 2.1). The strong lineaments of the Lesotho highlands are a result of widespread erosion of the basaltic lavas of the Karoo system by headwater streams of the Senqu/Orange River (King, 1942). Based on the premise that the Drakensberg escarpment originated at the Indian Ocean continental margin at the point of separation between southern Africa and South America, the mean rate of escarpment retreat would be *c.* 1 – 1.5km Ma^{-1}, however comogenic ^{36}Cl dating indicates that scarp retreat is an order of magnitude lower than previously thought (Fleming *et al.,* 1999).

The most ancient geomorphological unit in Lesotho is an old land surface, a remnant of the post-lava landscape, which forms the highest divides between drainage areas (Schmitz and Rooyani, 1987). A period of aggressive vertical erosion followed, removing almost the entire old land surface, and creating steep denudational slopes in the basaltic lavas (Table 2.1). Dissection of this landscape was interrupted by the formation of planation surfaces, which were accompanied by the retreat of valley walls (Schmitz and Rooyani, 1987) (Table 2.1). The resulting slightly inclined erosional surfaces were modified by slope wash and weathering (Schmitz and Rooyani, 1987). When progressive dissection reached the lower sedimentary layers, debris slopes with planation surfaces emerged once more. Overlying basalt layers eroded more rapidly than the resistant Cave Sandstones of the Clarens Formation, leaving a landscape of sandstone plateaus, mesas and buttes. Once the lowest planation surface had formed, a phase of general dissection began, resulting in deep, wide, rock-cut valleys that dominate the lowlands. Concurrent scarp retreat of the Clarens, Elliot and Molteno Formations left debris slopes at their base, whilst valley incision continued through headward erosion of waterfalls that formed at resistant sandstone and basalt outcrops (Schmitz and Rooyani, 1987). A period of colluvation followed, where eroded soils from planation surfaces, plateaus and rock shelves were transported downstream to form extensive fluvial accumulations, whilst filling up valleys with colluvium and alluvial deposits (Schmitz and Rooyani, 1987). incision occurred, although its magnitude was less than the initial period of valley incision. However, the same planation surfaces were stripped of their soils leading to the

Table 2.1: Summary of geomorphological events in Lesotho (Schmitz and Rooyani, 1987).

Formation of old land surface.
Valley incision. Shaping of major outlines and present valleys. Formation of denudational slopes in basalt.
Interruptions of the incision by periods of planation and valley widening by valley wall retreat. Formation of planation surfaces and denudational slopes in sedimentary strata.
Incision into the lowest planation surface. Formation of deep and wide, rock-cut valleys. Formation and headward retreat of waterfalls. Scarp retreat by rock fall and rock shattering. Formation of debris slopes.
Formation of deep soils under humid, warm conditions. Deposition of heavy clay layer on valley floors.
Widespread removal of soils by sheet wash from the planation surfaces and structural surfaces onto the adjacent lower lying units, mainly on footslopes, into valleys and depressions (pedisediments). Alluvial accumulation leading to the formation of the highest terrace (t_1) by often strong currents.
Incision into t_1. Renewed soil formation.
Removal by sheet wash of soils from the planation surfaces and structural surfaces onto adjacent lower lying units, mainly on footslopes, into valleys and depressions (pedisediments). Alluvial accumulation leading to the formation of the second terrace (t_2) with, towards the end, a period of humification. Formation of accumulation glacis.
Incision into t_2 and into pedisediments. Formation of erosion surfaces.
Alluvial accumulation leading to the formation of the lowest terrace (t_3).
Incision into t_3. Accelerated erosion, with gullying, rilling, sheet wash, rock stripping, soil slip and slumping Accelerated deposition as siltation, choking of channels, minor colluvation.

Subsequent valley incision occurred, eroding through the colluvial and alluvial sediments, with the base level of streams lowered to the base of the initial accumulations, although superimposition of rivers on underlying hard rock was common. Further stream deposition of an additional layer of colluvial material over existing pedisediments (Schmitz and Rooyani, 1987). This colluviation resulted in widespread fluvial accumulations, forming a second accumulation terrace surface. Subsequently, humification of the accumulation terrace occurred resulting in the distribution of black humified soils and localized peat deposits. Rivers and stream have incised these accumulations, with local erosion terraces being formed (Schmitz and Rooyani, 1987). Finally, a phase of stream accumulation occurred, resulting in formation of the lowest terrace with young, poorly developed soils. Once more, incision set in and continues to this day. Contemporary processes include accelerated erosion, characterized by gullying, rilling, sheet wash, rock stripping, soil slip and slumping (Schmitz and Rooyani, 1987).

2.5 History

The Basotho nation, formed 200 years ago, was a haven from the turmoil of the *lifaqane* wars that characterized central southern Africa at that stage, and continued to offer sustainable livelihoods for Sesotho-speaking people throughout conflict between Boer and British armies during the late 19th century (Showers and Malahleha, 1992; Turner, 2001). However, the protection of Basutoland by the British was at the expense of vast tracts of arable land in the Free State that were kept beyond the reduced territory of the kingdom's new boundaries (Showers and Malahleha, 1992; Turner, 2001). Displaced black South Africans began to move into the kingdom between 1890 and 1930, swelling an already crowded landscape and ultimately surpassing the carrying capacity of the land (Showers and Malahleha, 1992; Turner, 2001). Lesotho, which had served as an unskilled, low-wage labour reserve for South African mines, had to resort to an increasingly cash-based economy, as commercial farming was no longer viable. Whilst Lesotho has faced immense development challenges for several decades (Wallman, 1972), the country is now suffering severe land degradation and soil erosion as a result of increasing pressure from the growing population (Rydgren, 1988; Showers and

Malahleha, 1992), which is a situation common to many rural high mountain communities (Bloom and Sachs, 1998).

2.6 Infrastructure

It has been established that Lesotho lacks adequate infrastructure for industrial and commercial enterprises outside of urban centres, which is largely attributed to the shortage of technically trained professionals, the large gap between supply and demand of basic services, and a lack of investment in infrastructure projects (Government of Lesotho, 2005). The country compares poorly with other Southern African Development Community (SADC) states in terms of technology infrastructure including transport networks, cargo port infrastructure, and energy and communication networks (Government of Lesotho, 2005). Infrastructure service delivery in Lesotho is below the expected level for a country in Lesotho's income group, although Lesotho has exhibited progress with regard to provision of water and basic sanitation (Bogetic, 2006). However, failure to provide access to affordable or adequate infrastructure services to low-income groups is often associated with negative social impacts (Lawson, 2008). Individuals living furthest from public transport facilities and water sources tend to be among the poorest in Lesotho (Lawson, 2008). Despite the relatively sparse network of transport routes in Lesotho, participatory planning methods are being integrated with Geographical Information Systems (GIS) to prioritize road maintenance and devise alternate routes in remote mountain regions (Vajjhala and Walker, 2009).

Since the mid-1990s, Lesotho has received approximately US$ 44-million annually in royalties from South Africa by means of the Lesotho Highlands Water Project (LHWP), which diverts water from the Orange-Senqu River in Lesotho to Gauteng province in South Africa (Keketso, 2003). The LHWP is the largest infrastructure project under construction in southern Africa, providing 100% of Lesotho's energy needs through hydroelectric power generation at the 72MW Muela hydropower plant (Keketso, 2003). Despite the massive investment in the LHWP and the existence of several smaller hydropower plants, only 12% of all households and 1% of rural households have access to grid electricity (Taele *et al.,* 2007). The cost of electrification has increased in rural areas due to the mountainous terrain, sparsely populated regions and exposure of grid lines to thunderstorms and vandalism (Taele *et al.,* 2007).

2.7 Agriculture in Lesotho

Due to the prevalent misuse of land and mountainous terrain, only 9% of land in Lesotho is arable; the high-altitude plateau of Lesotho is suitable for grazing, and crop cultivation is limited to a narrow region in the western lowlands and foothills (Ministry of Natural Resources, 2000). Maize, sorghum, wheat, beans and peas are among the most important crops (Obioha, 2010). Herders in Lesotho utilize high-mountain grazing land during summer months, where private corrals and huts are used for this purpose. In winter, cattle are allowed to graze in communal regions closer to the settlements and villages (Swallow, 2003), although heavy snowfalls may limit grazing and lead to widespread stock losses (Turner, 2003). Cattle products, including wool and mohair, are produced and exported (Obioha, 2010). In the southern African region, rain-fed agriculture meets the food needs of many households, although it is often acknowledged to be a risky undertaking with low returns (Ferguson, 1985; Ziervogel and Calder, 2003). The adaptability and distribution of crops and crop type are strongly affected by existing interactions between physiographic features and the influence of the Atlantic and Indian Oceans, which significantly reduce the length of the growing season and erode agricultural productivity.

Cattle and other livestock are not simply regarded as economic commodities and valuable forms of social wealth, but occupy a far more important and embedded role in Basotho culture (Ferguson, 1985). There exists a distinct separation in household ownership of livestock, where cattle, goats, sheep and horses are considered ‘men’s animals’, and pigs and fowl are solely ‘women’s animals’. This is a largely unequal distinction of possession in which women are marginalized by their exclusion from decisions regarding the acquisition and sale of livestock (especially cattle) that often directly affects the entire household. Prevalent sex stratification and patriarchal social structures strongly limit the decision-making power of women in the household, and often hide the contribution of women to third-world agriculture while maintaining the image of female dependency on men (Safilios-Rothschild, 1985).

3. LITERATURE REVIEW

3.1 Introduction

Remote sensing techniques have emerged as valuable tools in the growing field of hazards research. Conflicting definitions and understanding of vulnerability have converged over the past two decades, with most vulnerability research incorporating a strong climate change focus. Satellite imagery is increasingly used to map hazards at a variety of scales ranging from district level (Espizua and Bengochea, 2002; Chakraborty *et al.,* 2005) to regional (Oberoi and Thakur, 2005; Pinto *et al.,* 2007) and continental scales (Margreth and Funk, 1999; Alcantara-Ayala, 2002; Podolskiy *et al.,* 2010). With an improved availability of satellite imagery, research into the spatio-temporal dynamics of snow has intensified, especially for mountain regions (Mulder, 2007; Haq, 2008; Brown, 2009; Negi *et al.,* 2009; Parajka *et al.,* 2009; Harshburger *et al.,* 2010; Mishra *et al.,* 2010; Prior and Kendon, 2011).

The general synoptic conditions that influence the Drakensberg climate are well established (Tyson *et al.,* 1976), and have been analysed at local and regional scales (Nel and Sumner, 2005; Sumner and Nel, 2006; Nel, 2008; Nel and Sumner, 2008; Nel *et al.,* 2010). In the adjacent Lesotho highlands, studies have documented the contemporary climatic systems (Sene *et al.,* 1998; Hydén, 2002) as well as historical climate variability in the region (Nash and Grab, 2010; Grab and Nash, 2010). The High Drakensberg, as a marginal periglacial environment, has generated considerable research on relict and active periglacial landforms and features since the late 1980s (Marker, 1991; Grab, 1998). Most of this work focused on reconstructing the Quaternary environment of the Drakensberg, with a particular focus on periglacial and glacial geomorphology (Grab, 1999; Boelhouwers and Meiklejohn, 2002). Consequently, literature over the last decade has centred on landforms associated with high altitude slope processes such as periglacial accumulations (Grab, 1999) as well as block streams (Boelhouwers *et al.,* 2002), relict sorted patterned ground (Grab, 2002a; Sumner, 2003), turf exfoliation (Grab, 2002b) and earth hummocks (Boelhouwers *et al.,* 2002; Grab, 2005). While the occurrence of snowfall in the Drakensberg has received superficial attention in the past, there has been growing interest in the spatio-temporal patterns of snow cover (Mulder and Grab, 2002, 2009; Mulder, 2007) and its associations with cold region landform distribution (Grab *et al.,* 2009).

3.2 The importance of snow

Harsh winters and low temperatures result in extensive snow cover for prolonged periods. At relatively low latitudes, snow cover is not permanent and undergoes rapid variations during the winter season (Chaponnière *et al.,* 2005). However, at higher latitudes, up to 40% of the land surface may be covered by snow during northern hemispheric winters, where snow cover depth and distribution remain fairly constant for extended periods (Brown, 2000). Parts of northern Europe often remain snow covered for up to 130 days (Jaagus, 1997). In Canada, for example, most regions are covered by snow depths of between 30cm – 100cm for many months of the year (Dickison and Daugharty, 1980), while the Arctic tundra has an average snowfall depth of 70cm (Bruland *et al.,* 2002). In the Australian Alps, snow may last a few weeks at elevations of 1200-1400m a.s.l, and may persist for up to four months at higher altitudes (1800-2200m a.s.l) (Whetton *et al.,* 1996). Snowfalls over the United Kingdom are frequently associated with freezing temperatures, and prolonged snow cover over widespread areas (Prior and Kendon, 2011).

In Alpine regions, snow has a pervasive influence on fauna, flora, hazards, and tourism activities (Brander, *et al.,* 2000). Snow cover plays a critical role in the hydrological cycle, affecting many physical, chemical and biological processes (Haefner, *et al.,* 1997; de Ruyter de Wildt *et al.,* 2007; Liang *et al.,* 2008). Monitoring snow cover extent plays an essential role in preventing disasters in agricultural areas where snow accumulation may result in the death of animals and people, and the disruption of transport and telecommunications infrastructure (Liang *et al.,* 2008; Joyce *et al.,* 2009). Flooding may also occur where snow has melted abruptly, posing a threat to low-lying regions and communities (Oesch *et al.,* 2002; Haq, 2008). Given its prevalence in high-latitude and altitude areas, snowfall represents a valuable resource in high-mountain environments, providing a considerable amount of downstream water supply as temperatures increase during summer (Haq, 2008). Snowmelt may contribute up to 80% of the annual discharge of some arctic streams and rivers, with many semi-arid and arid regions depending solely on snowmelt for the purposes of irrigation and power generation (Déry *et al.,* 2005).

Snow affects the exchange of moisture and energy between the atmosphere and the surface, and has a significant role in the earth's radiation balance as it has the highest albedo of any natural and spatially extensive surface (Painter *et al.,* 1998). Additionally, the presence or absence of snow cover is an important indicator of climate change (Haefner, *et al.,* 1997), impacts the length of plant growing seasons, and acts as a control on the soil thermal regime and atmospheric exchange of greenhouse gases (Dankers and De Jong, 2004). In high alpine environments, snow-cover data are widely used by individuals involved with resource management, construction work, risk analysis, and the evaluation of natural hazards (Etzelmüller *et al.*, 2001). Snow-cover data have valuable applications to weather prediction, hydrology, climatology, runoff prediction, reservoir management, and flood control (Haefner, *et al.,* 1997; Cline *et al.,* 1998; de Ruyter de Wildt *et al.,* 2007). Local water supply is strongly influenced by seasonal fluctuations in the extent of snow cover, as accumulated snow acts as a natural water reservoir (Chaponnière *et al.,* 2005; Haq, 2008). Therefore, accurate snow mapping and modeling of snowmelt and runoff is a vital first step in the mitigation of snow disasters and the reduction of economic losses in mountainous regions.

The dynamics of snow in semi-arid mountainous regions remain poorly understood. Despite the essential role snowmelt plays in supplying water to downstream regions (Haefner, *et al.,* 1997; Chaponnière *et al.,* 2005), the importance of snow cover coupled with seasonal fluctuations of its extent has highlighted the dynamic relationship between mountain communities, their livelihoods, and environmental and climatological controls. With the advances in modern remote sensing technology, digital mapping and snow telemetry, snowmelt runoff has become an important field of research (DeBeer and Pomeroy, 2009). This is especially the case in the northern Hemisphere, with its variety of high mountain ranges at high latitudes. With snowmelt providing the bulk of water needs in many mountainous regions, it is desirable to model variables such as snow-water equivalent (SWE) and snowmelt runoff; and to ensure economical and efficient use of valuable water resources (Anderton *et al.,* 2002; Shamir and Georgakakos, 2007).

3.2.1 Snow and climate change

The global warming of approximately 1°C during the 20th century has been attributed to an increase in atmospheric concentrations of greenhouse gases such as CO_2, oxides of nitrogen, methane, and chlorinated hydrocarbons (IPCC, 2007). CO_2 is the most important anthropogenic gas, as the atmospheric concentration of CO_2 is primarily affected by the use of fossil fuels and land use change. The increase in methane and nitrous oxide concentrations are mainly due to agricultural practices (IPCC, 2007). Coupled with declines in ocean and terrestrial CO_2 sinks, greenhouse gases have been steadily accumulating in the lower atmosphere at unprecedented rates and concentrations. These gases affect the heat budget of the atmosphere, the cryosphere, the world ocean and land surfaces (Epstein, 2004), and are associated with shrinking ice sheets and glaciers, rising sea levels, and increases in surface and ocean temperatures (IPCC, 2007). It is estimated that the warming and precipitation trends induced by anthropogenic climate change are responsible for 150,000 human deaths annually (Patz *et al.,* 2005). Many human diseases are linked to climate fluctuations, from respiratory illnesses due to heatwaves, to malnutrition from crop failures. Further, climate warming has altered the transmission of infectious diseases, precipitating changes in immunity and drug resistance (Patz *et al.,* 2005).

It is generally agreed that the changing global climate is likely to have far-reaching consequences on all sectors of society, as well as our immediate biophysical environment. While several of these effects have already manifested in mountain regions and elsewhere, the exact nature and extent of these changes are poorly understood. There is much uncertainty concerning the geographical distribution of vulnerability due to climate change, as well as the overall impacts of fluctuating temperatures on the global climate (Kropp *et al*., 2006). Thus, predictions of climate change based on GCMs present best- and worst-case scenarios, depending on the severity of the climate stress and severity of changes (IPCC, 2007). Therefore, new strategies are required, not only to analyse the rate and distribution of climate stresses, but also to address and inform planners and decision makers to prepare, adapt and mitigate against changing weather conditions.

It is acknowledged that snow surfaces experience considerable sensitivity to climatic anomalies and fluctuations and are important indicators of climate change (Beniston, 1997; Brown, 2000). The extent of snow cover area and its depletion is strongly linked to prevailing cumulative mean temperatures (CMT) (Singh, 2003). General circulation models (GCMs) predict significant warming during the winter season in high latitudes (Jaagus, 1997), which are expected to experience the greatest climate changes as a result of the so-called greenhouse effect (Whetton *et al.,* 1996; Dankers and De Jong, 2004). This is primarily due to the positive snow and ice albedo feedback mechanism which influences snowmelt in polar regions (Lefebre *et al.,* 2003). Mountains provide a unique setting for the detection of climate changes, and the assessment of climate-related impacts. This is because mountain microclimates change rapidly with height over relatively short horizontal distances, along with hydrology and vegetation (Beniston, 2003). To this end, snow patches are good indicators of climate change in temperate regions, integrating climatic inputs in both short and medium time spans (DeBeer and Pomeroy, 2009). Further, mountain regions around the world are now experiencing enhanced glacial retreat and widespread reductions in the duration and amount of snow cover (Bajracharya and Mool, 2007).

3.2.2 Temporal changes in snow cover

The northern hemisphere has experienced widespread shortening of the snow season, and decreases in snow amount following pronounced warming after the mid-1970s (Beniston, 1997; Epstein, 2004). For example, the European Alps have experienced a well-documented decrease in snow volume and snow duration since the 1960's (Prudent, 2007). Beyond normal inter-annual winter variations, this trend indicated the presence of some long-term winter cycles that are governed by shifts in large-scale forcings such as the North Atlantic Oscillation index (Beniston, 1997). The author relates these atmospheric fluctuations to multi-year episodes yielding high annual snowfall following episodes of lower annual snowfall. Labelled by some as an anthropogenic signal of climate change, the widespread decrease in Alpine snow cover was limited to regions with low to medium elevation (Beniston, 1997; Prudent, 2007). This is because snow accumulating in early winter at high altitude is less sensitive to unseasonable warming periods than at lower altitudes (Beniston, 1997). For example, in the eastern Swiss Alps, there is little variation in snow depth and distribution with respect to the long-term mean at altitudes above 2500m a.s.l (Prudent, 2007). An investigation of 12 locations in the Swiss Alps between 1945 and 1994 revealed that the length of the snow season and snow amount has decreased substantially over this period (Beniston, 1997). Snow cover research in the Apennine belt has revealed that the cryosphere of the summit area is rapidly shrinking (Pecci, 2007). Increasing temperatures have reduced the permanence of snow at low to medium altitudes, which has led to destabilization of snow surfaces and a subsequent rise in the prevalence of avalanches. Faced with decreasing snow cover, ski-slope tourism operators are forced to supplement their slopes with artificial snow, which is manufactured using local water resources (Pecci, 2007). However, competing socio-economic necessities have led to situations where drinking water uptakes conflict with uptakes for artificial snow production, such as in areas of the French Alps (de Jong, 2007).

By reconstructing historical snow cover depth and duration over 82 years, Brown (2000) provides evidence of a general twentieth-century increase in the snow cover extent of North America using *in situ* snow cover records and daily climatological observations from 1915 to 1997. However, it is argued that evidence of climate change declines with elevation in North America (Seidel *et al.,* 2009). In Canada and the Arctic, winter and early spring snow depths decreased significantly in the 1946-1995 period, with strong positive correlations emerging between changes in snow depth and duration (Brown and Braaten, 1997). This episode of snow cover change coincided with a well-documented shift in atmospheric circulation over the Northern Hemisphere during the mid-1970s (Beniston, 1997). It has been shown that snowfall duration and location is strongly influenced by the westerlies in the Chilean Andes, South America, where snowfalls difficult to characterize due to the strongly localized nature of regional precipitation (Vuille and Ammann, 1997). Polar outbreaks are tracked in an attempt to forecast heavier snowfalls in South America associated with cold surges (Pezza and Ambrizzi, 2005). Increased concentrations of greenhouse gases are expected to strongly influence the inter-annual variability of snowfall in the Australian Alps (Whetton *et al.,* 1996). Climate models reveal that prevailing temperatures control precipitation in the region, so a warming climate would likely enhance the effects of El Niño Southern Oscillation and local topographical effects. The Snowy Mountains of Australia are currently experiencing a warming of 0.2 K per decade, which is expected to significantly decrease the amount and duration of snow patches that have, in some cases, persisted for several years (Green and Pickering, 2009). An analysis of climate variability in Lesotho from 1833 – 1900 based on documentary evidence reveals that the frequency of snow-rich and severe cold seasons was lower in the latter 19th century than during the early part of the study period (Grab and Nash, 2010). Further, the authors argue that severe cold seasons in Lesotho tend to follow major volcanic eruptions in the Southern Hemisphere.

Up to 10% of the Earth's surface is permanently covered by glaciers (Dozier, 1989). With predictions of a warming climate, the distribution, seasonality and amount of snow and ice may undergo considerable changes in various geographic settings, owing mainly to the hydrological cycle being enhanced under warmer climatic conditions (IPCC, 2007). This has implications for river run-off in high-mountain catchments and lowland regions that are fed by upstream water courses (Beniston, 2003). The ice mass over the Himalayas is the third largest on Earth, and plays a major role in the economy and social structure of the central Asian region by providing considerable freshwater resources (Immerzeel, 2007). However, China has experienced a 5.5 % reduction in volume of its glaciers over the last 24 years, and even more rapid melting is predicted if the climate continues to warm at the current rate (Bajracharya and Mool, 2007). In the Himalayas especially, glacial melting has critical implications for hydrology in catchment areas, as seasonal increases in water volume may lead to flooding in low-lying agricultural regions (Immerzeel, 2007).

3.2.3 Topographic controls on snow distribution

The longevity of snow cover is dependent on available energy, which is affected by the incident elevation, aspect and slope of the snow surface (Cazorzi and Fontana, 1996; Jain *et al.,* 2009). In mountain areas, these topographic elements are often enhanced, and therefore snow cover is substantially variable in such environments (Hock, 2003). Altitude determines air- and surface temperatures as well as the amount and type of precipitation, and higher wind speeds are often associated with increases in altitude. In British Columbia, Canada, snow cover exhibits greater extent and duration with increasing altitudes, with maximum snowmelt rates occurring at lower altitudes (Tong *et al.,* 2008). Given that snow surfaces ablate more rapidly under warmer conditions, snow cover is likely to persist longer at high altitudes (Singh, 2003). The duration of snow cover is also affected by exposure to leeward winds and topographically controlled insolation levels (Andrés *et al.,* 2005). Since aspect determines the level of shading and exposure to prevailing winds, it has a considerable influence on the longevity of snow. For the western Himalayas, aspect plays a more significant role in determination of snow extent at lower altiudes than at higher altitudes (Jain *et al.,* 2009). In northern hemisphere mountains, snowmelt begins on southern slopes (180º), whilst in the southern hemisphere north-facing slopes (360º) experience faster snowmelt (Cazorzi and Fontana, 1996). In the High Drakensberg of southern Africa, snow cover is restricted to south-facing slopes (90 – 270º) after 7 days of ablation (Mulder and Grab, 2002). Strong relationships were found between snow cover and latitude, whilst a negative correlation exists between snow cover area and distance from the Drakensberg escarpment. In the Andes, for example, snow preferentially accumulates on south- and west-facing slopes, where it remains for extended periods of time (Espizua and Bengochea, 2002). These slopes thus exhibit high run-off yields during the snowmelt season, which consequently contributes to the formation of landslides and other geomorphic processes. Dickison and Daugharty (1980) have examined the relationship between topography and snow depth for the Canadian environment, and find a strong correlation between elevation and snow depth for most of the winter season. However, the quantity and depth of snow is influenced mostly by aspect towards the end of the winter season. The authors maintain that extreme or extraordinary events may significantly alter the relationships between snow depth and topographic variables in different environmental settings.

3.2.4 Hydrology and snow

Snow-cover data have valuable applications to weather prediction, hydrology, climatology, reservoir management, runoff prediction, and flood control (Haefner, *et al.,* 1997; Cline *et al.,* 1998; de Ruyter de Wildt *et al.,* 2007; Bavay *et al.,* 2009; Jain *et al.,* 2009). Snowmelt may contribute up to 80% of the annual discharge of some arctic streams and rivers, with many semi-arid and arid regions depending solely on snowmelt for the purposes of irrigation and power generation (e.g. Déry *et al*., 2005; Bavay *et al*., 2009). Snow ablation in arid mountains proceeds through the processes of snowmelt and sublimation (Schulz and de Jong, 2004). This change in phase is precipitated by decreased vapour pressure, and is enhanced by increasing wind speed or solar radiation. As wind speed increases and vapour pressure decreases with elevation, high-mountain environments are susceptible to excessive water loss through sublimation (Schulz and de Jong, 2004). Solar radiation is a critical input for hydrological and snowmelt models due to its effect on the energy balance of snow surfaces (Cazorzi and Fontana, 1996). The accurate characterization of basin hydrology is based on the interactions between multiple hydrometeorological variables (Anderton, *et al.,* 2002; Jain *et al.,* 2009), and variability in snow accumulation and ablation processes occurs at a variety of spatial scales (Anderton, *et al.,* 2002). In countries where a large proportion of energy requirements are fulfilled by hydroelectric power, changes in snow amount and duration have far-reaching implications for the provision of basic services and infrastructure (Beniston, 1997).

Basin hydrological models can be either physically or statistically based (Haq, 2008). Statistical models incorporate statistical relationships between inputs and outputs, whereas physical models describe the environmental processes that relate inputs to outputs. Subsequently, these models can be applied in a lumped or distributed mode. A lumped model describes catchment processes with single "catchment average" values. Distributed models divide catchments up into individual sections, and perform model calculations for each section (Haq, 2008). Snowpack depletion was modeled by Anderton *et al.* (2002) for a small headwater catchment in the Spanish Pyrenees. Although this study incorporated a strong spatial framework for snowmelt modeling, extensive manual snow surveys were undertaken without the use of satellite imagery. The authors did, however, incorporate a DEM into their grid-based distributed energy balance snowmelt model. For the Canadian Rocky Mountains, strong variability was found in the observed and modeled SWE due to localized topographic influences and resulting energy balance variations (DeBeer and Pomeroy, 2009). In the western United States, the influence of topographic variables (elevation, aspect and slope) were compared with satellite-derived snow cover maps to produce gridded-estimates of SWE (Harshburger *et al.,* 2010). This methodology is highly accurate and applicable to mountainous river basins, however it requires extensive datasets with high spatial and temporal resolution in order to function effectively in predicting SWE for wide areas.

3.3 Snow mapping

Snowfall and snow depth have always been difficult to quantify due to local variability, drifting, settling and melting between observations (Schmidlin, 1989; Cherry *et al.,* 2007). Prior to the era of satellite imagery and remote sensing technology, *in situ* snow measurements, field-based observations and documentary evidence provided the sole indications of snow depth and distribution (Repapis *et al.,* 1989; Pfister *et al.,* 1996; Brázdil *et al.,* 2005; Grab and Nash, 2010) (Table 3.1). Documentary evidence is often relied upon for very early climatic reconstruction, yet temperature series were recorded as early as the 17th century for some parts of England (Brádzil *et al.,* 2005). Descriptive observation of snow began in the early 18th century in Switzerland, and focused on the underlying stratigraphy of snowpacks (Pielmeier and Schneebli, 2003). Since 1881, Russian weather stations collected *in situ* measurements of daily snow depth with 1cm resolution by using snow-measuring rods placed in a meteorological enclosure (Kripalani and Kulkarni, 1999; Brown, 2000). Similar long-term records of monthly snow cover exist for 65 weather stations in China from the late-1800s up to 1993 (Brown, 2000). In 1887, snow gauges were installed in Los Angeles, California, but were used infrequently (Conner, 2006). By 1888, basic snowfall data were routinely recorded using snow-measuring rods at meteorological stations in North America (Changnon and Boyd, 1963), although Canadian weather stations only began recording snow-depth measurements in 1941 (Brown and Braaten, 1997). Snow gauges were widespread in North America by the late 1940s, but wind-induced turbulence over the gauge orifice reduced the amount of measured precipitation until windshields were added a few years later (Groisman and Easterling, 1994). These early snow measurements were further criticized for being biased toward populated areas and lower elevations, and for providing only localized data (Brown and Braaten, 1997). Conversely, snow depth records for the southern hemisphere are largely contemporary. For example, the record of observed snow depths in the Australian Alps started in 1955 (Whetton *et al.,* 1996). In some cases, South American meteorological records began in the early-1970s (Hardy *et al.,* 1998; Pezza and Ambrizzi, 2005), whilst large-scale radar measurements for the continent were only recorded since 1978 (Foster *et al.,* 2009). Widespread snow mapping in the Andes began in 1990 as part of climate change research initiative (Vuille and Ammann, 1997). However, documentary evidence of snow cover records and climate variability has been explored for Lesotho for the period 1833 – 1900 (Grab and Nash, 2010). By compiling and analyzing documentary sources such as newspaper articles and letters, the authors constructed a chronology of cold season snowfalls and climatic conditions for Lesotho.

Subsequent advances in snow measurement and mapping were driven by the requirement for accurate stream flow forecasts in regions where water supply is determined by seasonal melting of upstream snowpacks (Brown, 2009). The outdated practice of manual snow course surveys and measurements was gradually replaced in the 1980s by networks of automated snow telemetry (SNOTEL) stations, which provided near real-time climate and snowfall measurements (Brown, 2009). However, remote regions often lacked meteorological stations or were excluded from SNOTEL networks, and resulting measurements of regional snowfall characteristics were inaccurate or incomplete (Koskinen *et al.,* 1999). As technology advanced toward the end of the 20th century, satellite-borne sensors began to measure snowfall in unprecedented detail and extent (Brown, 2000). Further, remote sensing techniques are valuable tools for quantitatively assessing the spatial distribution and the dynamics of snowmelt in alpine areas with heterogeneous terrain (Dozier, 1989). Snowfall characteristics are increasingly measured with a combination of ground-based observations and remote sensing products such as aerial photography, radar and satellite imagery (Cherry *et al.,* 2007). However, *in situ* measurements are still relied upon on a daily basis for operational snow monitoring in many alpine environments (e.g. Palacios and Sánchez-Colomer, 1997; Li and Williams, 2008; Alcott and Steenburgh, 2010; Jonas *et al.,* 2009).

3.3.1 Aerial photography

Historically, aerial photography was the major source of remote sensing data, which were coupled with ground surveys to derive land cover characteristics (Haack and English, 1996). Aerial photography has distinct advantages in terms of high spatial resolution and accessibility, and developments in photogrammetry have upgraded this to a fully digital process (Etzelmüller *et al.*, 2001). Photogrammetric studies frequently use aerial photographs to analyse changes in land cover, as the data are easily integrated into a GIS with other spatial data (Evans *et al.,* 1989; Yohay and Ronen, 1998). With the proliferation of satellite platforms, aerial photography is commonly used to validate snow cover estimates from satellite-based sensors (Painter *et al.,* 2003). While aerial photographs are highly detailed and widely obtainable, imagery is not always available for remote regions, and often covers only small terrain sections (Kääb, 2002).

Sequential digital oblique photographs may be used to map snow cover, where images are orthorectified to a DEM and rasterized in order to perform statistical analyses using GIS software. Automatic cameras are placed on opposing hillslopes to obtain a daily record of snow cover in relation to local topography, and the images are subsequently georegistered using highly accurate DEMs. These methods have been successfully applied in the Passeier Valley of the Italian Alps (Tappeiner *et al.,* 2001), as well as in the Sierra de Guadarrama range of Spain (Andrés *et al.,* 2005). Corrected oblique photographs may have high spatial resolution of up to 1m, although such imagery is generally limited to smaller areas such as individual valley slopes. Aerial photographs and satellite data from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) were combined to produce multi-temporal DEMs of catchments in the Swiss Alps, to reveal vertical terrain changes associated with mass-movement (Kääb, 2002). This study highlights the importance of merging remote sensing data with DEMs, which allows for increased accuracy while mapping uneven mountain surfaces.

Light detection and ranging (LiDAR) data can provide accurate snow depth measurements when a snow-covered dataset and snow-free dataset are differenced, although LiDAR data collection is extremely expensive and requires expertise (Hood and Hayashi, 2010). Laser range finding systems are based on LiDAR technology but present an affordable and effective alternative for measuring snow depth in inaccessible regions without SNOTEL stations (Sovilla *et al.,* 2010). Whilst laser range finding systems have limited spatial coverage due to laser diffraction, laser distance data compares well with snow probe measurements (Hood and Hayashi, 2010).

3.3.2 Ground-based observations

Early snow measurements were strongly influenced by the topographic setting of gauges and meteorological stations, as slight changes in the position of snow gauges could have considerable effects on the amount of measured snowfall (Groisman and Easterling, 1994). To address the inaccuracies of past snowfall records, the Pan-Arctic Snowfall Reconstruction (PASR) model was developed to correct snowfall measurements for North America and Canada for the period 1940-1999 (Cherry *et al.,* 2007). The PASR model used observed snow depth and surface air temperature variables to reconstruct solid precipitation, and to compensate for snow gauge biases. Whilst the corrected records for the 1940–1999 period reveal both positive and negative changes in observed snowfall and snow depth, they provide a reflection of past physical snow accumulation with considerable accuracy (Cherry *et al.,* 2007).

Simple meteorological stations and snow mapping techniques became outdated by the late 20th century, and were slowly replaced by networks of automated snow mapping stations equipped with reliable and accurate sensors. These modern snow telemetry (SNOTEL) stations are capable of recording and transmitting hourly measurements and are equipped with pressure-sensitive snow pillows, precipitation gauges and air temperature sensors (Brown, 2009). In the Canadian Rocky Mountains, variables such as incoming radiation, air temperature, relative humidity, wind speed and direction, and precipitation are measured at meteorological stations (DeBeer and Pomeroy, 2009). Data from SNOTEL outposts are regularly used in conjunction with satellite-derived data, and are commonly applied to validate the accuracy of remotely sensed imagery (Johannson *et al.,* 2000; Liang *et al.,* 2008). Although *in situ* snowfall measurements are essential, as precise snow-depth information cannot be obtained from remotely sensed images, most ground-based snow measurements are still limited to individual catchment areas or basins, and even SNOTEL networks have limited coverage (Dozier, 1989). The extensive snow monitoring network in the Swiss Alps has recorded snow depth and density based on biweekly snow core measurements since the 1950s (Jonas *et al.,* 2009). By analyzing 5 decades worth of snow core records, a model was developed which accurately determined snow water equivalent (SWE) using snow depth observations as the sole input variable (Jonas *et al.,* 2009). Snow pits are generally used to analyse snow properties and measure SWE along transects (Evans *et al.,* 1989). In addition, a series of snow pits were established on the Pika Glacier, Alaska, to observe snow density and stratigraphy; these measurements were then blended with data derived from pulse-radar imaging and permittivity probes to construct vertical density profiles and stratigraphic maps of the glacial snow cover (Harper and Bradford, 2003). More recently, stratigraphic records from snow pits and cores from west-central Greenland were validated with subsurface radar observations to investigate snowpack properties (Dunse *et al.,* 2008).

Table 3.1: Chronological summary of historical and contemporary developments in snow mapping techniques.

Snow Mapping Techniques		Period								
		1800 - 1850	1850 - 1900	1900 - 1940	1940s	1950s	1970s	1980s	1990s	2000s
Ground-Based Observation and Measurement		▪ Stratigraphy ▪ Documentary records ▪ Descriptive analysis of snowpack	*In situ* measurements of snow depth using rods	Advancements in terrestrial photogrammetry	Widespread measurement of snow using gauges	Snow depth and density measurements from snow cores		▪ Snow Telemetry stations (SNOTEL) ▪ Ground penetrating radar (GPR) ▪ Automated Weather Operating Systems (AWOS)		▪ Advancements in Global Positioning System (GPS) technology ▪ Laser range finding
Remote Sensing Techniques	Aerial Photography		Invention of aerial photography		Airborne photogrammetry used for snow mapping				Development of digital photogrammetric techniques	
	Optical Satellites						▪ Landsat-1 ▪ NOAA - AVHRR	▪ Landsat 4 ▪ Landsat 5 ▪ SPOT-1	▪ Landsat-6 ▪ SPOT VGT ▪ MODIS Terra ▪ Landsat-7	▪ MODIS Aqua ▪ ENVISAT
	Radar Satellites						SMMR onboard Nimbus-7	SSM/I	SIR-C/X-SAR	▪ SRTM ▪ ENVISAT ASAR ▪ CryoSAT
	Hyperspectral Satellites							AVIRIS		Hyperion
	LiDAR									▪ LiDAR ▪ ICESat

During a traverse of Canada, Derksen *et al.* (2009) used a self-recording snow depth probe linked to a GPS (Global Positioning System). The probe was used to sample snow depth at hundreds of discrete points, with the precise position logged by GPS.

The United States government removed selective availability from its satellites in May 2000, which ended the deliberate degrading of the accuracy of GPS units (Bruland, 2002). This heralded a new era for high-resolution ground-based mapping, and GPS technology was swiftly applied to snow and glacier mapping applications (Gao and Liu, 2001). In the Czech Republic, snow depth measurements were made using a "stop and go" method that used a GPS to record the precise location of sampling points (Hejcman *et al.,* 2006). Differential GPS (DGPS) techniques were used to determine with high precision the position vector between two simultaneously observing GPS carrier phase-tracking devices. Current differential positioning requires one GPS receiver situated at a 'base station' of known location, whilst another mobile GPS receiver simultaneously tracks the same satellite signal. When the carrier phase data from the two GPS units are processed, the mobile receiver's co-ordinates are determined in relation to the stationary differential GPS unit (Hejcman *et al.,* 2006). Because snow surfaces act as planar reflectors of satellite signals, snow depth can also be inferred by multipath affecting the signal to noise ratio (SNR) of GPS antennae (Larson *et al.,* 2009). Snow depth is estimated using an algorithm where SNR is a function of snow density, satellite elevation angle, transmitted frequency, and the height of GPS antenna. Currently, there are many meteorological stations that have installed GPS antennae, which could be used to augment snow measurements from existing SNOTEL networks (Larson *et al.,* 2009).

With high-resolution and high frequency capabilities, terrestrial photography is an effective and economical alternative to conventional remote sensing techniques for environmental monitoring (DeBeer and Pomeroy, 2009). Even standard digital cameras can be used to capture oblique images of snow-covered slopes (Hinkler *et al.,* 2002). As the precursor to aerial photogrammetry, terrestrial photogrammetry was developed for mapping inaccessible terrain, where conventional theodolite surveys and aerial photography is unfeasible (Argawal, 1989). The use of terrestrial photogrammetric methods for glacial mapping was established in 1910 in Sweden (Holmlund, 1996), and contributed to glacial research in Norway (Knudsen and Theakstone, 1984) and the Himalayas (Argawal, 1989). Current terrestrial photogrammetric techniques involve the reprojection of oblique photographs onto high-resolution DEMs for spatial analysis (DeBeer and Pomeroy, 2009). Whilst terrestrial photography was initially used for stereoscopic mapping and orthophoto production, it is also used for snow cover mapping in remote alpine environments (Hinkler *et al.,* 2002; Palacios *et al.,* 2003). Contemporary applications have included the assessment of snow redistribution models (Hiemstra *et al.,* 2002; Corripio *et al.,* 2004) and measurement of snow surface albedo (Corripio, 2004).

Contemporary ground-based observations often include digital elevation models (DEMs), which are used to derive catchment areas, and topographic elements like aspect, slope and gradient. Large-scale DEMs are widely available, although the spatial resolution is often above 1km^2. However, they are useful for regional snowmelt mapping over wide areas, such as the Sierra Nevada (Shamir *et al.,* 2007). DEMs with higher spatial resolution have been used for snow modeling in individual catchments and smaller areas (Cazorzi and Fontana, 1996; Tappeiner *et al.,* 2001; Mulder and Grab, 2002; Dery *et al.,* 2005; DeBeer and Pomeroy, 2009; Grab *et al.,* 2009).

3.3.2.1 Ground Penetrating Radar (GPR)

One of the first applications of ground penetrating radar (GPR) to snow mapping was the Frequency Modulated Continuous Wave (FMCW) microwave radar system (Gubler and Hiller, 1984). The FMCW scatterometers were either buried underneath the snow facing up, or towed on skis facing downward and allowed for destruction-free observation of subsurface snow, from which it became evident that the FMCW system could measure snow depth and stratigraphy (Gubler and Hiller, 1984). FMCW radar has recently been used to capture the time evolution of avalanches in Switzerland, but in conjunction with speed and air-pressure measurements (Sovilla *et al.,* 2010).

The evolution of GPR technology from the early FMCW systems to current airborne and ground-based platforms is reviewed by Annan (2002). In the first study of its kind, a helicopter-based GPR sensor was used to measure snow accumulation on two Swiss glaciers, the measurements of which corresponded relatively well with ground-based snow profiling of the study area (Machguth *et al*., 2006). Arctic snow depth has been successfully measured using a GPR module coupled to a Differential Global Positioning System (DGPS) (Bruland, 2002), and impulse GPR measurements were acquired for Spitsbergen (Svalbard) to establish SWE and seasonal accumulation rates of snow over the period of 1997–1999, providing precise spatial snow depth records (Sand *et al.,* 2003). GPRs have provided accurate records of SWE, wetness and dry-snow density, whilst overcoming dry/wet snow classification challenges experienced by satellite-borne radar sensors (Bradford *et al.,* 2009).

3.3.2.2 Light detection and ranging

Light Detection and Ranging (LiDAR) data can provide accurate snow depth measurements when a snow-covered dataset and snow-free dataset are differenced, however such data collection is very expensive and requires considerable technological expertise (Hood and Hayashi, 2010). Laser range finding systems are based on LiDAR technology but present an affordable and effective alternative for measuring snow depth in inaccessible regions without SNOTEL stations (Sovilla *et al.,* 2010). Whilst laser range finding systems have limited spatial coverage due to laser diffraction, laser distance data have compared well with snow probe measurements (Hood and Hayashi, 2010). The Geoscience Laser Altimeter System (GLAS) instrument onboard the NASA Ice, Cloud and land Elevation Satellite (ICESat) has advanced capabilities for measuring vertical changes in sea and land ice with 15cm accuracy (Zwally *et al.,* 2002). In addition, the ICESat mission was specifically designed for observing long-term dynamics of polar ice-sheet volume (Zwally *et al.,* 2002; Schulze *et al.,* 2005; Yi *et al.,* 2011) and mapping glacier volume changes (Kääb, 2008), although the high-resolution GLAS instrument could potentially be used for mapping the extent and depth of snow surfaces.

3.3.3 Satellite imagery

Spaceborne remote sensing of the Earth's surface has effectively been undertaken since 1960, following the successful operation of the first of many meteorological satellites (Haack and English, 1996). The launch of the Earth Resources Technology Satellite (ERTS, later renamed Landsat) in 1972 heralded the first non-meteorological remote sensing platforms, which have been acquiring information from orbit for over 30 years (Haack and English, 1996). The proliferation of satellite-derived data products led to the scaling-up of global snow cover mapping, with the National Oceanic and Atmospheric Administration (NOAA) producing continental snow cover maps for the entire northern hemisphere (Robinson *et al.,* 1993). Whist snow data from ground station networks was relied upon exclusively in the past, satellite-based monitoring platforms facilitate the means to obtain truly global snow cover maps. A progression of more advanced sensors and modules followed, most notably Landsat and SPOT, with significant improvements in spatial resolution and spectral ranges (Mulders, 2001). With the widening availability of increasingly accurate satellite data, land-cover is increasingly mapped at global and continental scales with higher degrees of thematic content and spatial detail (Mayaux *et al.,* 2003).

The spatial distribution of snow-covered area (SCA) has crucial inputs into hydrological and climate models in alpine environments or areas experiencing seasonal snow (Painter *et al.,* 1998). Remote sensing has provided new opportunities to study the dynamic nature and variability of snow in these environments (Bishop *et al*., 2003). Snow cover extent has been mapped from a variety of operational remote sensing platforms with varying degrees of temporal and spatial resolution. The spectral sensitivities of each sensor are carefully matched to the end-user requirements and demands. For example, certain spaceborne sensors are precluded from snow and ice mapping in mountainous regions, where high spatial resolution is required to match the magnitude of topographic features (Albert, 2002).

Satellites are ideal platforms for remote sensing of snow cover due to their high spatial resolution, extensive spectral resolution and the ability to map large regions of the Earth at regular time intervals (de Ruyter de Wildt *et al.,* 2007). The synoptic view and repetitive, up-to-date coverage of satellite imagery is a powerful and efficient means of mapping the surface characteristics and dynamics of inhospitable or inaccessible areas (Gao and Liu, 2001). However, the selection of satellite imagery involves a series of trade-offs. To overcome these challenges, remote sensing studies may combine data products from multiple space borne platforms. Images of high spatial definition can preserve the subtleties of localized dynamics, while a high temporal resolution is valuable in analyzing seasonal trends on a larger scale. In this manner, the suitable characteristics of multiple imagery sources are accentuated, and unfavourable aspects can be nullified to some extent or at least be reduced. A clearer understanding of the dynamics of snow can be achieved through accurate and continuous mapping of the snow area by observing seasonal fluctuations, which allows the temporal and spatial dimensions of annual accumulation and ablation processes to be documented (Haefner, *et al.,* 1997).

Satellites are ideal platforms for remote sensing of snow cover due to their high spatial and spectral resolution, and the ability to map large regions of the Earth at regular time intervals (de Ruyter de Wildt *et al.,* 2007). The synoptic view and repetitive coverage of satellite imagery is an effective means of mapping the surface characteristics and dynamics of inhospitable or inaccessible areas (Gao and Liu, 2001). However, topographic and atmospheric effects cause distortions in the measured reflectance of surface features (Mishra *et al.,* 2010). High relief and densely forested regions are responsible for differences in scale, horizontal displacements and shadows (Buchroithner, 1995; Hall *et al.,* 1998; Vikhamar and Solberg, 2003). Cloud coverage prevents satellite-based optical sensors from mapping the underlying snow, whilst cloud shadows reduce the reflectance of surface features (Riggs *et al.,* 2006; Liang *et al.,* 2008). Further, the operating conditions of optical sensors are limited to fine weather and daylight hours, as they cannot observe the Earth's surface during darkness (Gao *et al.,* 2010). However, the application of topographic corrections including Minnaert correction, C-correction and slope-matching methods to remote sensing data can nullify the effect of differential illumination on snow cover mapping in mountainous terrain (Mishra *et al.,* 2010).

3.3.3.1 Radar

In the absence of SNOTEL networks or accurate *in situ* observations, snow extent can be measured by using radar technology. Furthermore, unlike satellite images, radar measurements can provide meaningful estimates of snow-depth regardless of cloud cover (Shi and Dozier, 1997). Although radar technology has existed for several decades, its applications for the measurement of snow and subsurface ice began to emerge in the mid-1970s (Annan, 2002). The first satellite-borne microwave sensor, the Scanning Multichannel Microwave Radiometer (SMMR), was launched in 1978 onboard the Nimbus-7 satellite (Robinson *et al.,* 1993). However, the SMMR sensor was operational for just under a decade and ceased operation in 1987. An additional passive microwave sensor known as the Special Sensor Microwave Imager (SSM/I) was launched onboard Defense Meteorological Satellite Program (DMSP) satellites in late 1987, and was used to determine snow extent and volume (Foster *et al.,* 2009). A lack of ground truthing information limited the applications of passive microwave data for regional and hemispheric snow mapping (Robinson *et al.,* 1993). Subsequently, studies have explored the use of SSM/I data in conjunction with topographic models and ground-based observations to increase the accuracy of passive microwave measurements. SSM/I data and multispectral Geostationary Operational Environmental Satellite (GOES) images were merged to create automated first-guess snow maps for the northern hemisphere (Romanov *et al.,* 2000). These snow maps were found to correspond well with *in situ* measurements taken from meteorological stations. SMMR and SSM/I images have since been used to measure seasonal snow mass and extent over Patagonia and the Andes in South America for the 1979 – 2006 period (Foster *et al.,* 2009). In a broader study, data from 71 meteorological stations in the northern hemisphere were compared with SSM/I imagery and digital elevation models to develop a prototype snow area and snow depth algorithm (Kelly *et al.,* 2003). This research proved that the development of a more accurate global snow area algorithm could be achieved by using data from the Advanced Microwave Scanning Radiometer (AMSR-E) sensor aboard the Earth Observing System (EOS) Aqua satellite. During a subarctic traverse of Canada, AMSR-E measurements were validated with *in situ* observations of snow depth, density, snow water equivalent (SWE), stratigraphy and grain size (Derksen *et al.,* 2009).

Interferiometric Synthetic Aperture Radar (InSAR) was the precursor to the Shuttle Radar Mapping (SRTM) missions of the early 2000s, and was frequently used for high-resolution mapping of snow and ice topography, independent of cloud cover and solar illumination (Rignot *et al.,* 2001). Launched in the early 1990s, the National Aeronautic and Space Administration (NASA) SIR-C/X-SAR (Shuttle Imaging Radar-C and X-Band Synthetic Aperture Radar) sensor has been used for measuring depth and temporal changes of wet snow (Shi and Dozier, 1997). The SIR-C provides detailed information about the geometric structure and dielectric property of a target. The SAR X-band adds far more information per pixel than fixed-antennae, single band SAR. For seasonal snow mapping in the Sierra Nevada, it was found that SIR-C/X-SAR data corresponds well with Landsat Thematic Mapper imagery, especially for mostly snow-covered pixels (Shi and Dozier, 1997). The first European Remote Sensing satellite, ERS-1 was launched in 1991 and was followed by the launch of ERS-2 in 1995, a new satellite platform for atmospheric ozone research (European Space Agency, 2010). Both ERS satellites are equipped with Synthetic Aperture Radar (SAR). ERS-2 SAR imagery was used in conjunction with NOAA Advanced Very High Resolution Radiometer (AVHRR) data to map snowmelt in northern Finland (Koskinen, 1999). While SAR snow maps were comparable to AVHRR snow maps, SAR data was well correlated to *in situ* snowfall measurements from meteorological stations in the study area. In a similar study, SAR images were used in northern Sweden, where it was established that SAR images could easily detect major changes in liquid water content of snow despite topographic variations (Johannson *et al.,* 2000). The authors placed specially constructed radar reflectors in the field to provide exact ground control points (GCPs), due to the lack of natural GCPs in the area. However, microwave sensors have an enduring difficulty depicting patchy or wet snow cover, and coarse spatial resolution precludes microwave sensors from mapping snow on regional scales (Robinson *et al.,* 1993; Nagler and Rott, 2000).

In response to increasing scientific interest in cryospheric variability, the ESA developed the CryoSat instrument that is equipped with a Ku-band Synthetic

Aperture Interferometric Radar Altimeter (SIRAL) (Drinkwater et al., 2003). More recently, CryoSat-2 was launched in April 2010, and is equipped with the SIRAL-2 instrument (an upgraded version of the original CryoSat SIRAL) capable of operating in three imaging modes (Cullen et al., 2007). Whilst the original CryoSat mission objective of measuring variability and trends of sea and land ice masses remains unchanged, the CryoSat-2 satellite is still in the commissioning phase and will only begin scientific data collection in September 2010 (European Space Agency, 2010).

The ESA ENVISAT satellite is equipped with the Advanced Synthetic Aperture Radar (ASAR) instrument, a multimode C-band SAR system with snow and ice mapping capabilities (Desnos *et al.,* 2000). ASAR SCA estimates that have been validated against MODIS and Landsat imagery and field measurements are comparable to the accuracy of SCA measurements made by optical sensors (Storvold *et al.,* 2004). The ASAR instrument can operate in three imaging modes (Desnos *et al.,* 2000) and data products may be used in conjunction with images from optical satellites due to comparable temporal and spatial coverage (Nagler *et al.,* 2008). However, ASAR data products have difficulty observing the effect of dry snow on C-band backscattering, and are rather suited to measure the extent of wet snow surfaces (Pettinato *et al.,* 2004).

3.3.3.2 Hyperspectral remote sensing

Hyperspectral remote sensing instruments allow snow grain size to be observed in single, narrow spectral bands (Nolin and Dozer, 1993). Snow properties such as albedo and surface radiation balance can be estimated through interpretation of hyperspectral data products (Nolin and Dozer, 1993; Green *et al.,* 1998; Nolin and Dozier, 2000). The Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) is an aircraft-mounted, hyperspectral sensor with 224 spectral bands, and provides imaging spectrometry data resistant to random electromagnetic noise (Green *et al.,* 1998). Snow albedo and surface radiation balance may be derived from AVIRIS imagery, and are important variables in snowmelt modeling (Nolin and Dozier, 1993; Nolin and Dozier, 2000). AVIRIS became an important tool for measuring the physical properties of snow, especially in extreme mountain environments where field measurements are unfeasible (Nolin and Dozier, 2000). Developments in AVIRIS classification techniques soon led to more accurate snow grain size measurements and the ability to map subpixel snow cover (Rosenthal and Dozier, 1996; Painter *et al.,* 1998). Snow albedo measurements derived from AVIRIS data have since been used as inputs for temperature index snowmelt models, which predict the timing and magnitude of snowmelt with considerable accuracy (Molotch and Bales, 2006). However, despite the hyperspectral properties of the AVIRIS sensor, it has difficulty mapping pixels that are not completely snow-covered or are obscured by vegetation (Nolin and Dozier, 2000).

The Hyperion hyperspectral visible/infrared spectrometer was launched on-board the Earth Observing-1 (EO-1) satellite in November 2000, with the capability of recording data in 242 discrete spectral bands (Pearlman *et al.,* 2003). Hyperion is used for on-board cryospheric measurement of changes in terrestrial ice, sea ice and snow cover (Doggett *et al.,* 2006). Whilst the autonomous Hyperion snow classification system has an accuracy of 76,5%, its measurement capabilities are somewhat limited in mountainous environments due to snow shading effects (Doggett *et al.,* 2006). Snow mapping studies based on Hyperion data are limited, as AVIRIS imagery is preferable for mapping snow due to its higher spatial resolution (1-2m pixel size) (Dozier and Painter, 2004).

3.3.3.3 National Oceanic and Atmospheric Administration – Advanced Very High Resolution Radiometer (NOAA-AVHRR)

Prior to the launch of the AVHRR sensor in 1972, existing NOAA snow charts often underestimated snow extent for the northern hemisphere, especially during autumn months (Robinson *et al.,* 1993). The AVHRR platform thus represented a major advancement in meteorological research by allowing constant monitoring of large areas with two daily acquisitions, with its 1.1km^2 spatial resolution being ideal for regional snow mapping applications (Vuille and Ammann, 1997; Lampkin and Yool, 2004). Early AVHRR data proved that satellite-based observations are able to provide accurate information of surface processes in the absence of ground observations and snow telemetry networks. Subsequently, NOAA developed the Numerical Weather Prediction (NWP) model, which uses AVHRR-generated snow maps as meteorological inputs (Romanov *et al.,* 2000). AVHRR data are also used to develop NOAA snow products for the Interactive Snow and Ice Mapping System (IMS) (Ramsay, 1998).

Using infrared radiance measurements derived from AVHRR sensors, snow surface temperatures can be calculated, and additionally serve as a proxy for calculating snowmelt (Oesch *et al*., 2002). This highlights the feasibility of such a platform for measuring snow extent over large areas, and suggests that *in situ* measurements are no longer required for accurate snowmelt mapping due to the increased sensor capabilities of remote sensing platforms. However, the relatively low spatial resolution, which is shared by all polar-orbiting satellites, affects the accuracy of snow classification over large areas, complex topography and variable land cover types (Foppa *et al.,* 2007). To this end, Foppa *et al*. (2007) developed a sub pixel snow mapping technique for AVHRR data in the European Alps, and validated low-resolution images with high-resolution Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) images. Whilst the sub pixel AVHRR snow maps compared well with the high-resolution images, the AVHRR maps still underestimated snow extent due to shade effects from mountainous terrain. Others found that snow cover data from the low-resolution of the AVHRR sensor compared poorly with similar products from higher-resolution platforms such as MODIS and Landsat, even after spatial and temporal tradeoffs were taken into account (Molotch and Margulis, 2008).

3.3.3.4 Moderate Resolution Imaging Spectroradiometer (MODIS)

The Moderate Resolution Imaging Spectroradiometer (MODIS) instrument operates onboard the Earth Observing System (EOS) satellites Terra and Aqua (http://modis.gsfc.nasa.gov). Terra and Aqua were launched in 1999 and 2002 respectively, with the purpose of studying geophysical features at a global scale, and mapping areal extent and albedo of global snow cover on a daily basis (Hall *et al.,* 1995, Wang *et al.,* 2006). The MODIS instrument possessed considerable advantages over similar operational snow mapping platforms due to its 500m spatial resolution and global coverage (Hall *et al.,* 2002). Such MODIS data are currently used in a broad range of land, ocean and atmospheric applications (Hall and Riggs, 2007).

MODIS accuracy tests revealed that the sensor could distinguish snow independent of cloud cover and complex topography, providing superior snow cover area (SCA) estimations to those from other operational platforms such as AVHRR and GOES satellites (Hall *et al.,* 2001; Maurer *et al.,* 2003). The MODIS snow product classification is based on the normalized difference snow index (NDSI) (Riggs *et al.,* 2006), which distinguishes between snow and clouds or other non-snow surfaces, due to the high reflectance of snow in visible wavelengths and low reflectance in the shortwave infrared wavelengths (Klein *et al.,* 1998; Salomonson and Appel, 2004).

MODIS snow cover products correspond well with other satellite data and ground-based observations in diverse environments such as Turkey (Tekeli *et al.,* 2005; Sorman *et al.,* 2007), China (Liang *et al.,* 2008) and Pakistan (Haq, 2008). MODIS products have difficulty mapping snow obscured by cloud or dense forests, yet the 500m pixel size and high temporal resolution are ideally suited to global snow mapping (Hall *et al.,* 2001; Parajka and Blöschl, 2008). Further, the spatial resolution of MODIS products can be increased by fusing the two 250m bands with the remaining 500m bands (Sirguey *et al.,* 2008). Similarly, fusing Aqua and Terra images and applying simple neighbourhood operators and temporal filters, the number of cloud-covered pixels can be reduced considerably (Parajka and Blöschl, 2008).

With growing interest in the effects of climate change on snow dynamics, MODIS multitemporal imagery is a valuable product when calculating interannual variability of snowfall in alpine regions (Reed *et al.,* 2009). It has also provided a platform for algorithm advancements, which include the development of snow cover products that combine high-resolution MODIS imagery with coarse-resolution AMSR-E microwave data (Foster *et al.,* 2007; Gao *et al.,* 2010). The resulting snow measurements are free of cloud obscuration but retain the high spatial resolution of the MODIS sensor. In addition, the recent development of a simple cloud-gap-filled (CGF) product further helps eliminate cloud cover from daily MODIS snow cover products (Hall *et al.,* 2010).

3.3.3.5 MODIS Rapid Response System

The MODIS Rapid Response System provides regular imagery of selected areas of the Earth's surface and was developed to meet the near real time needs of the applications community (Pinheiro *et al.,* 2007). With many of its products available online within hours of satellite overpass, the global dataset is automatically updated on a daily basis, making it a valuable source of spatial information for a variety of applications. Most of the MODIS Rapid Response imagery is delivered at 250m, 500m and 1000m resolution, which allows more flexibility and variety than the standard MODIS snow products. The near real time data products are invaluable sources of information during hazardous geophysical events, such as dust storms, floods, hurricanes and fires, where urgent action and emergency assistance is required. The Rapid Response System's flexibility in terms of data products, subsets, projections and formats allows high-volume users to access custom land-cover products that are not available through standard MODIS processing (Pinheiro *et al.,* 2007).

Several composite images are freely available from the Internet (http://rapidfire.sci.gsfc.nasa.gov/subsets), combining various wavelengths into a single image to highlight different land-cover types represented by reflected surface radiation (Haq, 2008). Of these false- and true-colour composites, the MODIS band 7-2-1 combination is useful in the visual identification of snow, as it appears bright blue. Bare soil appears red, water as black, and vegetation as bright green. In this case, bands 7-2-1 are assigned to red, green and blue elements of the spectrum respectively (Haq, 2008).

Using imagery from the Rapid Response System, Pinheiro *et al,* (2007) have successfully adapted the standard MODIS Land Surface Temperature (LST) algorithm for use with Rapid Response data products. The authors describe LST as an important variable in describing the energetic state of the Earth's surface, so near real time LST data have considerable benefits for hydrological, ecological and biogeochemical applications. The authors show how data from the Rapid Response System have accuracy comparable to that of the standard MODIS product suite, but with a latency of up to a few hours (compared to a latency period of 2 days for standard MODIS products). More recently, MODIS Rapid Response images have been used in mapping snow dissipation in the Kalam River Basin, northern Pakistan (Haq, 2008). The area of interest was extracted from the MODIS scenes by using image-processing software. Further, pixels were classified as snow by means of supervised and unsupervised classification techniques. Although this research has a major focus on hydrological modeling, it includes a remote sensing component that strongly supports the use of Rapid Response imagery for snow mapping due to its spectral sensitivity and 250m spatial resolution.

3.3.3.6 Landsat

The Landsat Thematic Mapper (TM) is a multispectral scanning imaging module onboard the Landsat 4 and 5 satellites, with the Enhanced Thematic Mapper Plus (ETM+) sensor currently operating onboard the Landsat 7 satellite (http://landsat.gsfc.nasa.gov/about/landsat7.html). Landsat has a repeat orbit of 16 days, and TM images are acquired in six nonthermal bands with 30m spatial resolution and one thermal band with 120m resolution, whilst the ETM+ sensor has an infrared band with 60m resolution. Band ratios for distinguishing between snow and other land cover types were swiftly developed to exploit the spectral capabilities of the Landsat sensors (Dozier, 1989). The Landsat NDSI was developed through analysis of the spectral characteristics of snow, which reflects visible radiation more strongly than middle-infrared radiation (Hall *et al.,* 1995), and was designed for operational mapping of snow cover area whilst discriminating between cloud cover and snow. With growing interest in the extent and characteristics of glaciers, Landsat imagery has been widely used for multitemporal mapping of glaciers in the Andes (Albert, 2002), the Peruvian Cordilerra Blanca (Silverio and Jacquet, 2005), and for analyzing snow zonation on icefields in Patagonia (De Angelis *et al.,* 2007). The high resolution of Landsat images has also facilitated the analysis of seasonal depletion of snow cover in the Swiss Alps (Brander *et al.,* 2000) and high Drakensberg, South Africa (Mulder and Grab, 2009). Despite advancements in optical remote sensing technology, Landsat products are reliable and robust sources of land cover information, and are still used to derive land cover maps for contemporary snow cover research (Hall *et al.,* 1998; Nagler *et al.,* 2008).

3.3.3.7 Le Système Pour L'Observation de la Terre (SPOT)

The SPOT-1 satellite was launched in 1986, and contained three spectral bands with 20m spatial resolution (Begni *et al.,* 1987). This unprecedented spatial resolution was complemented by dual High Resolution Visible (HRV) sensors that enable the recording of stereoscopic image pairs (Begni *et al.,* 1987). Accurate DEMs could be derived by stereo-matching the SPOT image pairs, although this process was still in its infancy and required validation (Day and Muller, 1989). However, with the launch of successive SPOT satellites, advances in stereoscopic capabilities enabled the production of DEMs with considerably higher accuracy (Bouillon *et al.,* 2006). Spot panchromatic images have a 10m pixel size, and were thus applied to snow, ice and glacial mapping in alpine environments (Buchroithner, 1995).

The VEGETATION (VGT) instrument was launched on-board SPOT-4 in 1998, and used for mapping wide areas while retaining good temporal and spectral coverage (Mayaux, 2003). The VGT sensor provides daily coverage of the Earth's surface at 1-km spatial resolution, and can easily identify snow cover based on its reflectance in the visible and near-infrared spectral bands (Dankers and De Jong, 2004). Following the launch of VGT, a Normalized Difference Snow/Ice Index (NDSII) equivalent to the Landsat NDSI was developed based on studies in China (Xiao *et al.,* 2001) and Fennoscandia (Dankers and De Jong, 2004). Subsequently, VGT data became widely used for regional snow and ice mapping in Canada (Simic *et al.,* 2004), North and

Central America (Latifovic *et al.,* 2004), and the Atlas Mountains in Morocco (Chaponnière *et al.,* 2005; Boudhar *et al.,* 2009).

3.3.3.8 ENVISAT

The Medium Resolution Imaging Spectrometer instrument (MERIS) and the Advanced Along Track Scanning Radiometer (AATSR) onboard the European Space Agency (ESA) ENVISAT satellite have a range of snow mapping applications (Malcher *et al.,* 2003; Pepe et al., 2005). The MERIS 15-band optical instrument has a spatial resolution of 260 × 290m, greater than SPOT VGT and AVHRR sensors, although it cannot accurately distinguish cloud and snow cover as it lacks short-wave infrared channels (Tampellini *et al.,* 2004). However, the AATSR instrument has two spectral short-wave infrared bands which are suitable for snow mapping, yet the 1-km^2 spatial resolution limits the applications for localized snow mapping (Tampellini *et al.,* 2004). By combining the medium-resolution of MERIS data with the spectral characteristics of AATSR data, Pepe *et al.* (2005) adopted a multisource interpretation scheme to measure snow cover in alpine regions at regional and catchment scale. Snow maps derived from MERIS and AATSR data have proven considerably accurate, particularly for hydrological modeling (Malcher *et al.,* 2003; Tampellini *et al.,* 2004).

3.4 Hazards

The International Strategy for Disaster Reduction (ISDR) defines a hazard as “a potentially damaging physical event, phenomenon or human activity, which may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation” (ISDR, 2004, p5). Once this physical, social or environmental disruption unfolds, it is termed a “disaster” if the losses incurred exceed the abilities of affected communities or societies to cope using their own resources (ISDR, 2004, p5). The increasing incidence of hazards precipitated by extreme weather events, such as volcanic eruptions, landslides, earthquakes, floods, avalanches or any other geophysical event which may threaten human lives and livelihoods, is already well documented (Riebsame *et al.,* 1986). However, the danger is not only the result of the hazard occurrence, but also the result of human systems and their associated vulnerabilities towards them (Alcántara-Ayala, 2002).

3.4.1 Hazard mapping

A hazard map delineates threatened areas and assigns them to different hazard categories depending on the frequency and expected impact or severity of hazard events (Gruber and Bartelt, 2007). Proximity to the source of threat, duration, and spatial impact are also key variables for assessing hazard impacts (Cutter, 1996). However, it is becoming more common to analyse the spatial extent of several factors such as vulnerability and risk, and relate these elements simultaneously to multiple hazards (Collins *et al.,* 2009). Given that most geophysical events vary in magnitude both geographically and temporally, associated coping strategies must be variable and iterative to mitigate against the shifting boundaries of hazard zones (Holub and Fuchs, 2009). Aerial photographs and satellite-derived imagery are commonly used for mapping the extent of geophysical threats and delineating areas which have been, or may be, affected by such events (Espizua and Bengochea, 2002). Remotely sensed imagery can also highlight spatial changes over time, providing information on the changing size, extent and influence of hazardous events. However, many environmental hazards are unpredictable in terms of their spatial impact, speed or duration (Cova and Church, 1997). As environmental dynamics are critical to hazard mapping, so too are social impacts and responses, which are measured by threats to lifelines or infrastructure to support basic needs, and by socioeconomic indicators such as health and income (Cutter, 1996). Hazard maps focus primarily on geophysical elements of hazards, such as location and spatial extent, whilst vulnerability assessment studies place more emphasis on population data with reference to affected communities.

The role of geographic information systems (GIS) has been highlighted over the past few decades, as researchers grapple with understanding the complex and dynamic relationships within and between multiple social and biophysical systems (Evans *et al.,* 1989; Koczot and Dettinger, 1999). One of the great powers of GIS is the ability to consolidate and compare geospatial data from different eras and multiple sectors of the information universe (Stowell Bracke *et al*., 2008). Proven to be a valuable analytical tool, GIS technology gained popularity with advances in processing power, decision-support tools and applications that cater for a broad spectrum of scientific and commercial interests. GIS software enables users to create and access databases, compare data statistically and spatially, and visualize the resulting products and images (Karimi and Houston, 1997). Since the proliferation of satellite-derived data over the past four decades, GIS tools are commonly used in conjunction with digital elevation models (DEMs), digital topographical maps and remote-sensing data for mapping (Mulders, 2001). Coupled with decreasing software costs, the utility of GIS for hazard mapping and disaster management is increasing (Zerger and Smith, 2003), and "transnational risk analysis" has become possible (Collins *et al.,* 2009:459). Because hazards are multi-dimensional issues that have spatial components, GIS is a well-suited tool for delineating hazard boundaries and other characteristics (Zerger, 2002). Scientists are able to streamline high-volume data capture whilst performing complex analytical forecasts such as natural hazard modeling, hazard zonation, and ecological simulations (Oberoi and Thakur, 2005). Continual development of programming technologies have enabled GIS software to integrate seamlessly with the Internet to provide end-users with vast sources of geospatial data (Karnatak *et al*., 2007). However, risk assessments, hazard models and management decisions that are derived from GIS outputs are entirely dependent upon the accuracy of the original input data (Zerger, 2002). Acknowledging these limitations, Collins *et al.* (2009) discuss the challenges of building GIS databases using demographic information derived from multiple countries, where incongruent census statistics limited the number of variables which could be used to compare vulnerability between two countries. This study used GIS analysis to generate neighbourhood-level maps of biophysical hazard, risk and social vulnerability maps once the incompatibility issues had been addressed.

Hazardous climatic events have long been the subject of modeling, especially for establishing the extent of damage and the predicted cost of repair and mitigation. However, such modeling has occurred mainly in urban centres, where climate forecasts and weather data are more accessible than in rural areas. Further, the adverse effects of severe climatic events such as heavy snowfall are likely to be greater in towns and cities, due to a higher concentration of infrastructure and population. In the mid-1970s, Howe and Cochrane (1976) developed a decision model for minimising the costs involved in adjustment and residual damage caused by non-catastrophic events, such as heavy snowfall. Using several American cities as case studies, climate forecast data were integrated with the capacity and resources of local authorities, which were indicators of preparedness during heavy snowfalls. Estimating the cost of repair and adjustment require several key variables, which include the probability and duration of snowfall events, and the resources required for managing snowfall incidents.

3.4.2 Snow as a hazard

Heavy snowfalls are often associated with the onset of extremely cold conditions, and can pose a significant threat to humans, livestock and property (Kääb, 2002; Prior and Kendon, 2011). Urban areas are particularly susceptible to the disruptions of snowstorms (Rooney, 1967) as roofs and electrical power lines collapse under the weight of snow, roads become blocked, and people may remain isolated for long periods (Pinto *et al.,* 2007). The snow hazard is defined as "comprising all the perils that snow and ice present, both in themselves and in association with other weather conditions" (Rooney, 1967, p538). Mountain regions prone to frequent, heavy snowfalls are particularly susceptible to associated hazards, such as ice avalanches, collapse of infrastructure, and restriction of movement. In parts of Asia, and more particularly the Himalayas, the magnitude of avalanche disasters is rapidly increasing as urban growth extends into hazard zones (Sharma and Ganju, 2000). The exploitation of land for habitation and agricultural purposes within known avalanche tracks has led to increased fatalities and damage to infrastructure (Richardson and Reynolds, 2000; Oberoi and Thakur, 2005). Even in Africa, historical and contemporary accounts of severe snow in Lesotho have recorded human deaths, heavy livestock losses and damage to fruit trees (Grab and Nash, 2010).

Avalanches and landslides caused by snowmelt are frequent in the South American Andes, where unstable snow and debris represent continual hazards for populated centres, highways and bridges (Espizua and Bengochea, 2002). South America is regularly affected by polar air outbreaks that are accompanied by freezing temperatures and heavy snowfall, resulting in widespread negative impacts on agriculture and primary production (Pezza and Ambrizzi, 2005). Documentary evidence for Lesotho from 1833 – 1900 indicates frequent crop damage and livestock losses as a result of heavy snowfalls and severe weather conditions in the region (Grab and Nash, 2010). Several parts of Afghanistan experienced severe cold and heavy snowfalls during December 2007 and January 2008 (IFRC, 2008), during which time the Red Cross Society recorded 30 fatalities from exposure to extreme cold, although many more people were injured. Eleven of these deaths were caused by a snow slide in the western region of Afghanistan. In addition, several dwellings were destroyed, roads blocked, and 900 sheep lost. The situation was exacerbated by high numbers of internally displaced people who required emergency shelter (IFRC, 2008). Such snow-related phenomena are well described for the European Alps where avalanches frequently occur, causing considerable damage to property and in some cases fatalities (Lehning *et* al., 1999; Margreth and Funk, 1999; Gruber and Bartelt, 2007). During the 2005/6 winter season, abnormally heavy and persistent snow fell in Germany, resulting in the collapse of several homes, and the falling roof of an indoor skating arena which killed fifteen people and injured 50 others (Pinto *et al.,* 2007). However, subsequent thawing of this snow affected parts of Austria, Germany and the Czech Republic as dams broke and thousands of people had to be evacuated (Pinto *et al.,* 2007). The United Kingdom recently experienced unseasonably heavy and widespread snowfalls, which were accompanied by freezing temperatures and prolonged snow cover (Prior and Kendon, 2011). These heavy snowfalls resulted in widespread travel delays, traffic accidents and disruption to water and electricity supplies. In parts of the Himalayas the magnitude of avalanche disasters is increasing at a rapid rate as urban growth extends into hazard zones (Sharma and Ganju, 2000). Even land within known avalanche tracks is exploited for habitation and agricultural purposes, leading to higher occurrences of fatal casualties and heavy damage to infrastructure in this region (Richardson and Reynolds, 2000; Oberoi and Thakur, 2005). In a global study, Podolskiy *et al.* (2010) compiled documentary evidence of regions susceptible to avalanches caused by earthquakes. However, regions near quarries and mines were also found to be at risk of snow avalanches resulting from ground motions associated with the use of explosives for mining purposes (Podolskiy *et al.,* 2010).

3.4.3 Early Warning Systems (EWS)

Whilst focusing on disasters is important for providing assistance to affected communities, identifying and measuring risks before disasters occur is an essential strategy for effective and sustainable disaster-risk reduction (Birkman, 2007). Early warning systems forecast impending events, process and disseminate warnings to authorities and communities, and initiate appropriate and timely actions in response to the warnings (ISDR, 2004). Despite the devastating social impacts of environmental disasters, such events often precipitate severe economic crises that may have been averted by some form of early warning system (Tachiiri *et al*., 2008). However, global methods for identifying and measuring vulnerability to disasters are not sufficiently developed, which has important implications for defining disaster-risk management and disaster-relief priorities (Birkman, 2007). An inclusive and comprehensive early warning system remains problematic to develop, mainly due to considerable data inputs and a lack of understanding of the complex teleconnections between environmental processes (Rabuffetti *et al.,* 2008). The integration of early warning systems into disaster management strategies represents a further challenge because most warning systems are context-specific, and deal with single environmental hazards in geographic isolation. Systems must be designed to incorporate a broad scope of factors relevant to the risk, whether arising from social vulnerabilities or natural hazards, and from long-term to short-term processes (Basher, 2006). Initially, the extent of hazards must be accurately mapped, and an understanding of the scale of potential impacts is necessary. The sustainability of early warning systems relies on strong political commitment and durable institutional capacities, which in turn require good public awareness and an appreciation of the importance of early warning systems (Basher, 2006).

Due to numerous recent heavy snowfall events, several authors have attempted to develop early warning systems for snow-related hazards. Arid mountain regions in Mongolia commonly experience harsh winter conditions that occasionally lead to widespread debilitation and death of livestock, with devastating consequences for the livelihoods of herders (Tachiiri *et al.,* 2008). The authors analysed the timing and distribution of these climatic disasters, and used the Normalized Difference Vegetation Index (NDVI) as well as Snow Water Equivalent (SWE) variables to develop an early warning system for drought coupled with severe winter conditions. Austria already has comprehensive early warning systems in place, which are effective because of their linkages to legislation and municipal finance through well-established institutional frameworks (Holub and Fuchs, 2009). Following catastrophic avalanches in Switzerland during the winter of 1950/1951, the IFKIS (Interkantonales Frühwarn- und Kriseninformations- System) early warning system was implemented (Bründl *et al.,* 2004). IFKIS represents a combination of hazard mapping, forecasting, and organizational procedures such as evacuation, traffic diversions, and internet-based communication for safety services. The IFKIS has performed considerably well during subsequent snowfall events, and highlights the importance of organizational measures informed by accurate snow mapping and analysis (Bründl *et al.,* 2004).

The Lesotho Meteorological Services (LMS) is a government agency that is responsible for collecting weather data, providing daily forecasts, and distributing warnings of extreme weather events (LMS, 2007). Due to the constantly changing climate, real-time meteorological observations and forecasts must be disseminated rapidly to wide audience. The LMS accomplishes this by using mass media, which includes television, radio and newspapers; while certain user groups may be targeted by means of email, telephone, facsimile and the Internet. Television is the preferred medium of sharing weather forecasts, as its graphical interface makes climatic processes more understandable to the public. With the increasing effectiveness and accessibility of the Internet as a source of information, the LMS has begun to provide online weather warnings and reports of extreme events over the last few years (LMS, 2007a-e).

With existing predictions of adverse environmental impacts associated with global climate change, seasonal climate forecasts can be valuable in establishing climatic trends, thereby providing information and preparing for climate variability (Ziervogel and Calder, 2003). These forecasts allow local authorities to make informed decisions, and assist rural communities to adopt effective strategies to secure existing livelihoods in the face of fluctuating and changing rainfall and temperature trends. It is acknowledged that early warning systems for natural hazards require not only a sound scientific and technical basis, but must also focus on the people exposed to risk (Basher, 2006). To this end, the Southern Africa Vulnerability Initiative (SAVI) was developed to explore the interactions between multiple stressors and livelihoods, by understanding the context in which vulnerability is experienced (O'Brien *et al.,* 2009). This 'contextual vulnerability' approach acknowledges that certain communities or individuals are disproportionally affected by shocks, and identifies strategies to reduce such risks.

3.5 Vulnerability

Vulnerability is the degree to which a system, subsystem or component is likely to experience harm due to a hazard, stessor or perturbation (Turner *et al.,* 2003). It is a manifestation of the inherent states of the system (e.g., physical, cultural, social, organizational) that may be exploited to adversely affect the system (Haimes, 2006). The basic concept of vulnerability is essential in hazards research, and it is a critical input for hazard mitigation strategies at the local, national and international level (Cutter, 1996). Vulnerability in the context of global change can be applied generally or specifically, from individual vulnerability to a particular hazard, to the vulnerability of humankind to all hazards (Smit and Wandel, 2006). As vulnerability implies the potential for loss, and losses vary geographically and between different social groups; vulnerability varies over time and space (Cutter *et al.,* 2003). People become vulnerable when they encounter social and environmental hazards, whilst the extent or degree to which individuals are adversely affected by a hazard depends on the adaptive capacity or resilience of these individuals (Smit and Wandel, 2006). Risk can be viewed as a product of three main elements: exposure to hazards, the frequency or severity of the hazard, and the vulnerability of those exposed to the hazard (Birkman, 2007). However, some contention exists regarding the definition of 'vulnerability'. Current definitions have been criticized for being both too broad by including too many categories and too narrow as they exclude others at risk for different reasons and classifications (Levine, 2004). Further, an integrated approach is required for assessing the effects of multiple stressors on households and communities (O'Brien *et al.,* 2009), and confusion over key terms such as *vulnerability* and *risk* must be avoided (Heltberg *et al.,* 2008). With growing evidence of negative impacts associated with climate change, the importance of local adaptation, household coping mechanisms and community-based mitigation strategies has been increasingly emphasized (Thornton *et al.,* 2008; Heltberg *et al.,* 2009).

3.5.1 Measuring vulnerability

Vulnerability indicators are commonly single variables, although multidimensional factors like food aid, institutional development, social relations or political power may also be employed (Cutter, 1996). Traditionally, such assessments of vulnerability focus on individual elements of risk contributing to overall vulnerability. However, communities and individuals face multiple risk factors at any time, and hazard studies must acknowledge the interactions between multiple stressors acting simultaneously at a household level (O'Brien *et al.,* 2009). Threats to households may be direct (climate change) or indirect (e.g. increasing food prices, exposure to disease, environmental degradation), yet interventions frequently concentrate on direct risks and exclude the significant influences of indirect threats on livelihoods (Heltberg *et al.,* 2008). Further, there exists confusion over definitions of key concepts used in hazards research (Heltberg *et al.,* 2009). Future vulnerability assessments must incorporate monitoring of potential hazards and community responses; predictions of potential consequences; identifications of policy alternatives, and subsequent modifications to institutional arrangements (Heltberg *et al.,* 2008).

3.5.2 Vulnerability and livelihoods

Livelihood choices and household economic decisions are interwoven with the need to manage environmental risks, especially for low-income households in rural areas (Heltberg *et al.,* 2009). Further, mountain communities face multiple biophysical hazards, and vulnerability to these threats is dependant on a variety of socioeconomic and geographic indicators (Foggin *et al.,* 2006). Sustainable livelihood analysis emerged as a means of reducing poverty through documenting environmental and social dynamics at a household level (Eakin and Luers, 2006). It is a useful tool in environmental change research, as it facilitates the differentiation of vulnerable populations according to their assets and entitlements. Conceptually, livelihood studies reveal which assets are critical in coping and adapting to risk, and how livelihood strategies are linked within the social and environmental context (Eakin and Luers, 2006). The focus on livelihoods within vulnerability research has intensified over the last decade, responding to the impacts of a changing climate coupled with food shortages in many developing countries and widening economic inequalities (UNDP, 2007). In sub-Saharan Africa, vulnerability 'hotspots' have been identified in agricultural zones on a continental scale (Thornton *et al.,* 2008). This study highlights the necessity of sub-national vulnerability assessments, given the considerable heterogeneity of households' adaptive capacities. Sustainability science and global environmental change studies have recognized the need to address the significant changes taking place in a variety of environmental settings and contexts (Turner *et al.,* 2003), particularly where a series of extreme (and often permanent) conditions exist which impose significant fragility on the livelihood activities carried out by certain social groups and communities (Cardona, 2004). The level of development attained and the success of development planning strategies determine the extent and severity of these conditions. Increasingly, hazards researchers have turned their attention to issues of vulnerability and risk, emphasizing the importance of intersecting social systems and geophysical conditions (Chakraborty *et al.,* 2005), especially in the face of climate change predictions (IPCC, 2007). However, the understanding of how climate change affects vulnerability and risk is limited, and the precise nature of the hazards associated with changing climate require more clarity

(Heltberg *et al.,* 2008). Community-based programmes for adaptation and mitigation must evolve to take a 'no-regrets' approach, that will incorporate strategies that reduce vulnerability and mitigate against future environmental impacts and climate change (Heltberg *et al.,* 2009).

Southern Africa is home to many resource-poor communities who are exposed to a number of environmental and socio-economic stresses (Bloom and Sachs, 1998; Reid and Vogel, 2006; O'Brien *et al.,* 2009; Obioha, 2010). Many of these environmental factors, such as drought, flooding and harsh weather conditions, are immediate causes of poverty in Lesotho, and are often met with aid and relief efforts from outside organizations (Turner, 2001; Obioha, 2010). Periods of climate stress usually expose multiple factors contributing to an increased vulnerability to environmental change, including deteriorating social networks, poor access to basic resources, and other governance and structural factors influencing vulnerabilities (Reid and Vogel, 2006; O'Brien *et al.,* 2009). Poverty in this instance is defined as "the lack of empowerment to achieve a secure livelihood" (Turner, 2001, p3). It is thus the pastoral households, those receiving at least half their household gross revenue from livestock or livestock-related activities, that are most vulnerable to the dynamic nature of the climate and environment in Lesotho (Swallow, 2003). However, climate variability is just one of the multiple stresses and shocks that can increase the vulnerability of rural communities (Ziervogel and Calder, 2003). These challenges are mostly related to the sensitive nature of mountain ecosystems and finite natural resources (Malik and Hunzai, 2005), while loss of life and livestock may occur when subsistence farmers are faced with extreme climatic events (Turner, 2003). Presently there is a considerable need for increased understanding of how climate change impacts the resiliency of low-income, rural communities dependent on subsistence agriculture, especially in resource-poor regions of Africa (Thornton *et al.,* 2008; O'Brien *et al.,* 2009).

3.5.3 Vulnerability in Lesotho

The Basotho have been faced with severe socio-economic challenges, which extend to health problems, poverty, criminality, and malnutrition (Turner, 2001:ix; O'Brien *et al.,* 2009). The negative impacts associated with historical climate variability in Lesotho have recently been reviewed (Nash and Grab, 2010; Grab and Nash, 2010). Given that most of the developmental and socio-economic challenges have their basis in Lesotho's troubled history, the negative effects have escalated over time, becoming more conspicuous. From the mid-1980s, it was acknowledged that the kingdom was experiencing rural poverty as a result of decreasing agricultural yields (Safilios-Rothschild, 1985). The semi-permanent absence of males as a result of migration to South Africa for employment opportunities is cited as a major contributing factor, as the economy is largely dependant on remittances and not on subsistence agriculture (Safilios-Rothschild, 1985). Even at this stage, animal husbandry and pastoralism were evidently placing increasing pressure on rangelands. This is described in Ferguson's (1985) analysis of cropping and livestock in the foothills and highlands of Lesotho, where acute soil erosion is experienced as a direct result of overstocking. Further, agricultural activities are highly dependant on prevailing weather conditions, and are therefore unreliable sources of income due to recurring droughts and unreliable rainfall in Lesotho (Ferguson, 1985). There have since been attempts to institutionalise an agricultural curriculum in the primary school education system, in order to transform educational institutions into productive and economic institutions (Monyooe, 1994). However, this goal is obscured by insufficient funds for structural adjustment, outdated teaching and learning methods, and rampant migrant labour. Moseley and Earl (1997) identify declining food self-sufficiency, acute shortage of wood fuels, rapid erosion and the rapidly expanding population as additional barriers to development. Lesotho, like many other developing countries, faces major challenges in the provision of safe drinking water and effective sanitation. These shortcomings in service delivery are the combined result of a lack of communication between government ministries, meagre funds allocated to rural areas, and insufficient technical capacity to implement projects (Kravitz *et al.,* 1999). Therefore, rural communities that lack access to improved water sources are exposed to water-related diseases such as diarrheal illness on a daily basis. With increasing understanding of multiple stressors that face southern African communities as a direct result of climate change, the South African Vulnerability Initiative (SAVI) was developed to assess vulnerability interventions and identify strategies that effectively increase resiliency against environmental change (O'Brien *et al.,* 2009).

Lesotho is experiencing a severe HIV/AIDS epidemic, with high prevalence among young women and men (Gouws *et al.,* 2008). The high rate of HIV has eroded traditional coping mechanisms and social networks, and is compounded by poorly funded and mismanaged government prevention strategies (Nyabanyaba, 2008; Piot *et al*., 2008, p846). Colvin and Sharp (2000) maintain that prevalent sexual networking patterns and lack of access to treatment are significant contributing factors to the spread of HIV/AIDS, as the effects of the epidemic appear far greater in urban centres than in remote rural communities (Piot *et al*., 2008). High prevalence of HIV/AIDS compounds existing health issues to further erode household food security and coping mechanisms, especially in poor, rural households (LVAC, 2002). This is confirmed by Mphale *et al.* (2002), who argue that HIV/AIDS illness not only impacts agriculture, but also other sectors of producing or accessing food. The loss of regular income is said to be the most immediate impact of HIV/AIDS on households (Mphale *et al*., 2002). The high prevalence of HIV/AIDS amongst young adults has resulted in a depletion of human capital, loss of labour, increased household spending on health care, diversion of resources from agriculture, and an eroded capacity to care for future generations (Renzaho, 2006; Nyabanyaba, 2008; Piot *et al.,* 2008).

3.5.3.1 Food security

Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (World Food Summit, 1996). However, food insecurity remains a persistent challenge to most of southern Africa (FFSSA, 2004; Bryceson and Fonseca, 2006; Romero-Daza *et al.,* 2009), mainly due to unfavourable and unpredictable climatic conditions (Eckert, 1983). Food insecurity among Basotho households increased significantly between late 1970 and 1995, primarily as a result of import and price policies applicable to the staple grain sector (Makosholo, 2005). Before 1995, there was extensive intervention by the state in the marketing, processing and production of agricultural goods. This policy environment resulted in the distortion of market signals and incorrect allocation of resources, so the ability of the private sector to engage in the market on a competitive basis was severely weakened (Makosholo, 2005). Subsequently, these challenges led to a major decrease in productivity and almost uncontrollable poverty among Lesotho's farmers. The country was struck by a severe food shortage in 2002, which was part of a regional crisis precipitated by drought, consecutive poor harvests and low rainfall throughout southern Africa (SADC, 2002). Estimates stated that 30% of the Basotho population would require emergency cereal food assistance through to March 2003 (SADC, 2002). Faced with high prices and increasing shortages of food, households adopted alternative strategies like brewing and selling beer, and selling livestock and firewood. Households may also rely on social networks of family members and friends for support, although many are forced to migrate to South Africa or Maseru in search of food. Whilst most of southern Africa experienced an increase in the production of food cereals in 2003, Lesotho was the only country that reported a significant decrease (FEWSNET, 2003). However, as the country has a reasonable road network, it is acknowledged that food aid can be efficiently targeted and transported to affected communities. The kingdom subsequently experienced three years of erratic weather patterns, culminating in the decision by the Government of Lesotho to declare a state of emergency in February 2004, following a substantial decrease in maize production (LVAC, 2004; SADC, 2004). Once again, large numbers of households were exposed to severe staple food shortages, and foreign aid was urgently required. Erratic weather in 2005 meant that 70% of the cropping area in Lesotho was unplanted due to late rains (IFRC, 2005). Better crop conditions during the 2006 season resulted in increased crop production, but while the total population facing food insecurity decreased significantly over this period, thousands of households remain vulnerable to acute food shortages (FEWSNET, 2006). The onset of the 2007 growing season was marked by well-distributed rainfall, which led to widespread water-logging in the lowlands (SADC, 2007). This water rapidly receded after several dry spells that followed these heavy downpours.

Indeed, sub-Saharan Africa is susceptible to chronic food crises and famines that are triggered by the slightest drought, flood or economic downturn (FAO, 2006). Low-income households may spend 60-80% of total income on food purchases in this region that is experiencing a widespread decrease in household food production and an increase in dependence on market purchases (Baipethi and Jacobs, 2009). This trend is clearly evident among poor, rural households in Lesotho, which face considerable food insecurity due to myriad socio-economic and environmental factors (Molapo, 2009). A large proportion of able-bodied males are employed as migrant workers on South African mines, and the high HIV/AIDS prevalence rate has depleted the agricultural workforce (Romero-Daza *et al.,* 2009). The small proportion of land that may sustain agriculture has been severely degraded, and poverty is widespread, particularly affecting rural communities in the highlands (Makhanya, 2004). Lesotho has a long history of declining productivity and dependence on food imports, but food shortages, the latest challenges in a series of socio-economic crises, are becoming increasingly common (Eckert, 1983; Ferguson, 1985; UNRIACSO, 2004; Makosholo, 2005; Renzaho, 2006). Over 80% of the Basotho population derive livelihoods from agriculture, yet only 5% of households engaged in agriculture are able to produce sufficient food to meet their requirements (Swallow, 2003; FFSSA, 2004). In less than a decade, domestic food production has scaled down considerably, and the country now imports 70% of its annual staple-food requirements, mainly from South Africa (Mashinini and De Villiers, 2001; Romero-Daza *et al.,* 2009). During 2004, communities in the highlands experienced a 30% decline in the supply of wild foods, which normally contribute 15% of household food needs (LVAC, 2004). This deficit was attributed to inhibited plant growth due to a lack of moisture from inadequate winter snowfall.

As a nation vulnerable to the adverse effects of climate change, Lesotho has a considerable need for increasing the facilitation of access to technical knowledge and the transfer of skills in order to meet the provisions set out by the United Nations Framework Convention on Climate Change (UNFCCC) (Ministry of Natural Resources, 2000). In meeting these challenges, several barriers to technical transfer and innovation have manifested in Lesotho and other developing countries. National development objectives have been limited in most economic sectors by difficulties in creating employment and sustaining incomes; elements mainly attributed to limited arable land, unreliable climate, mountainous topography, and a rapidly increasing population. While studies have explored the effects of climate forecasts on smallholder food production and resiliency, there are no government strategies to improve household food security in Lesotho (Ziervogel, 2004; Ziervogel *et al*., 2005). The relationships between climate variability and reduction in agricultural potential remain largely unexplored for Lesotho (Obioha, 2010). Food aid organisations such as the World Food Programme (WFP) are operating effectively in the country, but have been criticized for providing unsustainable safety nets for beneficiaries, as households become dependant on food aid (Molapo, 2009). However, if subsistence agriculture could be encouraged and supported, it may provide the key to delivering secure and sustainable food to households in Lesotho (Baipethi and Jacobs, 2009).

Whilst Lesotho has faced considerable climate variability in the past (Nash and Grab, 2010; Grab and Nash, 2010), contemporary climate change is expected to increase the likelihood of extreme events, such as droughts and flooding, with shifting precipitation and temperature patterns causing hotter and dryer conditions, especially in the western and northern lowlands (Government of Lesotho, 2000; LVAC, 2002). The kingdom has little to offer economically other than cheap labour, and some mineral and diamond deposits (UNCTAD, 2003). As such, the country has a strong dependence on subsistence agriculture, which is based on animal husbandry and high pasturing (Grab and Nüsser, 2001). The implications are evident in the highlands, where 60% of households were classified as "poor", receiving 15% of their food needs from gifts and aid in 2003 (LVAC, 2004). Communities in lower-lying regions of Lesotho, such as the Lowlands and Senqu River Valley, are considerably less vulnerable to the effects of severe cold and snow, although economic conditions remain comparably depressed in the lowlands.

Lesotho faces multiple hazards with regard to food security, and high climate variability is a key factor characterizing the present challenges of food security, poverty and healthcare (LVAC, 2004). Several regional structures and mechanisms aim to address these vulnerabilities by predicting food deficits and highlighting affected regions. The Southern African Development Community (SADC) has released several emergency food security assessment reports through its Vulnerability Assessment Committee, detailing food aid requirements for countries in the region. Lesotho is repeatedly at risk because of low productivity associated with land degradation (SADC, 2002). Between 2002 and 2003, Lesotho's domestic cereal deficit was 255,500MT and 30% of the population required emergency food aid, and HIV/AIDS was cited as a major factor increasing vulnerability to these acute food shortages (SADC, 2002). In conjunction with the SADC, Lesotho maintains its own vulnerability committee that releases seasonal Livelihoods-Based Vulnerability Assessments (LBVA). These assessments are a more detailed version of the SADC regional reports, and provide in-depth statistics on domestic food markets including prices, cereal deficits, and food security issues (Lesotho LBVA, 2003). Lesotho's LBVA assesses the food requirements of its population based on household data. The impact on food security of HIV/AIDS, access to basic services, education, healthcare and other multi-sectoral issues are explored, although data on household savings and financial resources are still severely limited (Lesotho LBVA, 2003).

3.5.3.2 Rural livelihoods

The main source of risk for subsistence and commercial agriculture in mountain environments is high variability in seasonal climate, characterized by frosts or extremely cold spells (Srinivasan, 2000). Most of the population in Lesotho is directly dependent on the land for survival. Consequently, livelihoods and living standards are closely entwined with the state of the environment, although many of the existing environmental problems are symptoms of natural resource exploitation, such as clearing land for expanding agriculture and human settlements, collecting firewood, and supporting livestock (Ministry of Natural Resources, 2000). The rangelands of Lesotho have long been under pressure from intensive stock rearing and subsistence cropping (Ferguson, 1985), which is commonly experienced in other mountain environments such as the Himalayas (Allen, 1986). These actions accelerate the removal of vegetation, thereby increasing rates of erosion and run-off, decreasing biodiversity, and lowering agricultural productivity in general. Ultimately, rural communities are most affected by such environmental degradation (Allen, 1986).

In a case study of the Sani plateau region of Lesotho, Grab and Nüsser (2001) note that the highland socio-economy can be severely affected by long-lasting snow patches, firstly due to loss of livestock and human life, and secondly due to loss of high pasturing land. Further loss of income may occur when snow prevents access to livestock-driven trade routes through high-mountain passes, and when the production and trafficking of dagga (marijuana) is prevented by similar snowfall events.

4. METHODOLOGY

4.1 Introduction

Multiple datasets have been analyzed in various combinations to accurately represent snowfall and its various impacts on human vulnerability. The data requirements demanded extensive snow cover information, as well as detailed spatial information on the location of human settlements. Remotely sensed images with high and low spatial and temporal resolutions are manipulated to determine seasonal and spatial trends in snow dissipation. Digital maps and additional spatial data are combined to represent the location of villages, key infrastructures, and general topographical features throughout Lesotho. Satellite images and settlement data are incorporated into a Geographic Information System (GIS), which facilitates image processing, data manipulation, and clear visual representation of complex relationships between multiple data inputs (Koczot and Dettinger, 1999). For the purposes of image manipulation, classification and analysis, two GIS suites were used in conjunction. IDRISI® Kilimanjaro™ (Version 14.02) is a powerful GIS with good manipulation and visualization capabilities, and was a valuable tool for initiating batch-processing commands and facilitating image classification. The ESRI® ArcMap™ 9.3.1 suite contains valuable tools for analyzing spatial statistics and trends, and is also useful for the creation of vector layers, image rectification and database creation.

While many of the image processing techniques are similar to the methods of Mulder and Grab (2002; 2009), Haq (2008) and Grab *et al.* (2009), new methods have been employed which incorporate remote sensing data of higher spatial resolution and temporal spread. Multi-temporal imagery is analyzed, and the SNOMAP and NDSI algorithms (Hall *et al.,* 1995) have been applied to MODIS Rapid Response 250m resolution images, which is unique to this study. Finally, a comprehensive spatial snow database is presented in the context of spatial human settlement patterns in Lesotho.

4.2 Constraints

One of the major obstacles confronted was the shortage of accessible spatial information for Lesotho. Data scarcity includes detailed topographical maps, digital elevation and terrain data, and the location of human settlements. Although some spatial datasets for the country are available on the Internet, they are often of poor spatial or temporal resolution. Much of the high-quality spatial information, for example Digital Elevation Models (DEMs) and Digital Terrain Models (DTMs), has been gathered by private organizations and companies, and is therefore prohibitively costly or unavailable to the public. Alternatively, user-created DEMs can be made by hand-digitizing individual contour lines off topographical maps, then using a concatenation module in GIS software to generate an altitudinal surface with interpolated altitude values. Despite this process being exhaustive for an entire country, the lack of topographical maps for Lesotho completely excludes user-created DEMs in this case.

Fruitless visits by the author to the Department of Environmental Affairs and Mapping in Maseru meant that 1: 50 000 maps of the country could not be obtained. The absence of high-resolution topographical data meant that other sources of lower-resolution information had to be used. One of the key sources of topographical data was a 1: 250 000 digital map of Lesotho (Lesotho Government, 1994). However, despite the large area represented by this map, it is very detailed and compares favourably with other sources of spatial data from Lesotho.

High-quality remote sensing data is often difficult to obtain due to cost and limited coverage. While low-resolution satellite imagery is widely available at almost no cost, high-resolution remote sensing data are very expensive due to extensive automated image processing and rectification. The Satellite Applications Centre (SAC) in Hartbeeshoek, Pretoria, provided a limited number of SPOT images for research purposes at no charge. The prohibitive cost of ordering satellite imagery from private suppliers excluded further images from being purchased. Although satellite imagery catalogues contain all the images captured by the relevant sensor, only a small percentage of these images provide coverage of the study area and an even smaller proportion may be used to map snow cover. Images must meet several criteria before they are included in the research database. Each satellite image must:

- provide coverage of the study area,
- contain sufficient traces of snow surfaces,
- not be obscured by cloud or smoke,
- form part of a sequence of images recording a distinct snow event.

The intervals between satellite overpasses have limited the number of snowfall events captured by the SPOT satellite. SPOT images are generally 1–4 days apart. While most snow in Lesotho lasts a few days or more, snow generally disappears from low-lying areas after a few days, especially during late-season events. Further, the presence of cloud and smoke has limited the number of images used in this study. Many MODIS and SPOT images had to be excluded because of widespread cloud cover or smoke. In these cases images cannot be classified accurately because cloud cover and snow have a similar spectral reflectance.

Although SPOT imagery has a higher spatial resolution than MODIS data, it only provides coverage of a $60km^2$ area. Thus, several SPOT images are necessary for the same surface area represented by a MODIS image. The trade-off between spatial resolution and temporal resolution is an example of the compromises inherent in geospatial research that may be overcome by using multi-resolution datasets.

4.3 Temperature data

Mean daily and nocturnal air temperatures were calculated based on hourly recordings from a Davis Instruments® Vantage Pro 2™ weather station located at approximately S29°35'1.50", E29°17'24.13" in Lesotho on the escarpment near the head of Sani Pass at an altitude of ≈2900m a.s.l. Hourly measurements were recorded using Weatherlink™ 5.8.3 data-logging software. The temperature record ranges from 2000 to 2010, however no temperature data are available for 2003 and 2008, including the second half of 2007. Mean day-time temperatures were calculated for the 12-hour period 06:00 – 18:00, whilst mean nocturnal temperatures were calculated for two 6-hour periods: 00:00 – 06:00 and 18:00 – 00:00 respectively. However, temperature data acquired from this weather station provides an indication of broad climatic conditions in Lesotho, and is used only to make relative comparisons between snowmelt rates and air temperatures.

4.4 Topographic data

Several digital 1:50 000 topographical maps showing segments of South Africa and Lesotho were used to georeference a scanned 1:250 000 topographical map of Lesotho. Four digital maps were selected for this purpose: 2827DD Ficksburg, 2828DD Mont-Aux-Sources, 3027AB Magalengbrug, and 3028AB Qacha's Nek. Because spatial reference systems were already defined for the 1:50 000 digital maps, they were used to provide Ground Control Points (GCPs) to georeference the 1:250 000 map. GCPs are points of known latitude and longitude, and commonly consist of visible landmarks or significant lines of intersection such as road or railway crossings, rivers and bridges. On each of the four 1:50 000 maps, 10 GCPs were identified, yielding a total of 40 shared points of known spatial location with which to reference the 1:250 000 map. The process of updating the spatial reference system for the larger map was accomplished using the ArcGIS *Georeferencing* tool, which produced a fully referenced 1:250 000 digital topographical map of Lesotho with an average Root Mean Square (RMS) error of 0.013.

A high resolution DEM with a 50-metre pixel size was obtained from the South African Council for Scientific and Industrial Research (CSIR). This DEM was spatially clipped to a digital outline of Lesotho's national border to exclude unnecessary data from analysis. The nearest neighbour sampling technique from ArcGIS *Management Tools* was used to resample the original DEM into two separate raster images: one DEM with 10m-pixel size (to match the spatial resolution of SPOT imagery), and another DEM with 250m-pixel size (to match the spatial resolution of MODIS imagery). Subsequent processing and classification of these DEMs was identical, with the exception of the two different spatial resolutions of the derived products. The resampled DEMs were reclassified into 50m vertical classes, resulting in separate images composed of 48 distinct altitude bands. ArcGIS Spatial Analyst *Surface Analysis* module was then used to extract components of aspect from the DEMs.

4.5 Villages and settlements

A digital shapefile containing location, name and district attributes of 2016 villages was obtained from Mr. Lehlohonolo Moeti in the Geography Department at the National University of Lesotho. The shapefile consists of a vector layer comprising point locations of each village, and its presence in one of 10 districts: Berea, Butha-Buthe, Leribe, Mafeteng, Maseru, Mohale's Hoek, Mokhotlong, Qacha's Nek, Quthing and Thaba-Tseka. The village shapefile was manipulated using GIS for analysis in relation to snowfall extent and topography. Further, the digital village shapefile was used in conjunction with road data (Figure 4.1) to determine the proximity of each village to major and secondary roads. The overall vulnerability of villages is expressed for early, mid and late season snowfalls by assigning a palette of graduated colours, indicating the vulnerability ranking of each village.

4.6 Major and secondary roads

Access to transport routes is a key factor affecting human vulnerability to snow. During heavy snowfalls or prolonged snow coverage, blocked roads may isolate villages whilst delaying rescue or relief efforts. Villages that are located further from accessible roads have increased susceptibility to these impacts. Therefore, it is assumed that vulnerability to the negative impacts of prolonged snow cover is determined by the proximity of a village to roads. However, despite the proximity to roads, snow cover may block transport networks and render all nearby roads unusable. Therefore, the duration of snow cover on roads was analyzed as an additional indicator of vulnerability for individual villages.

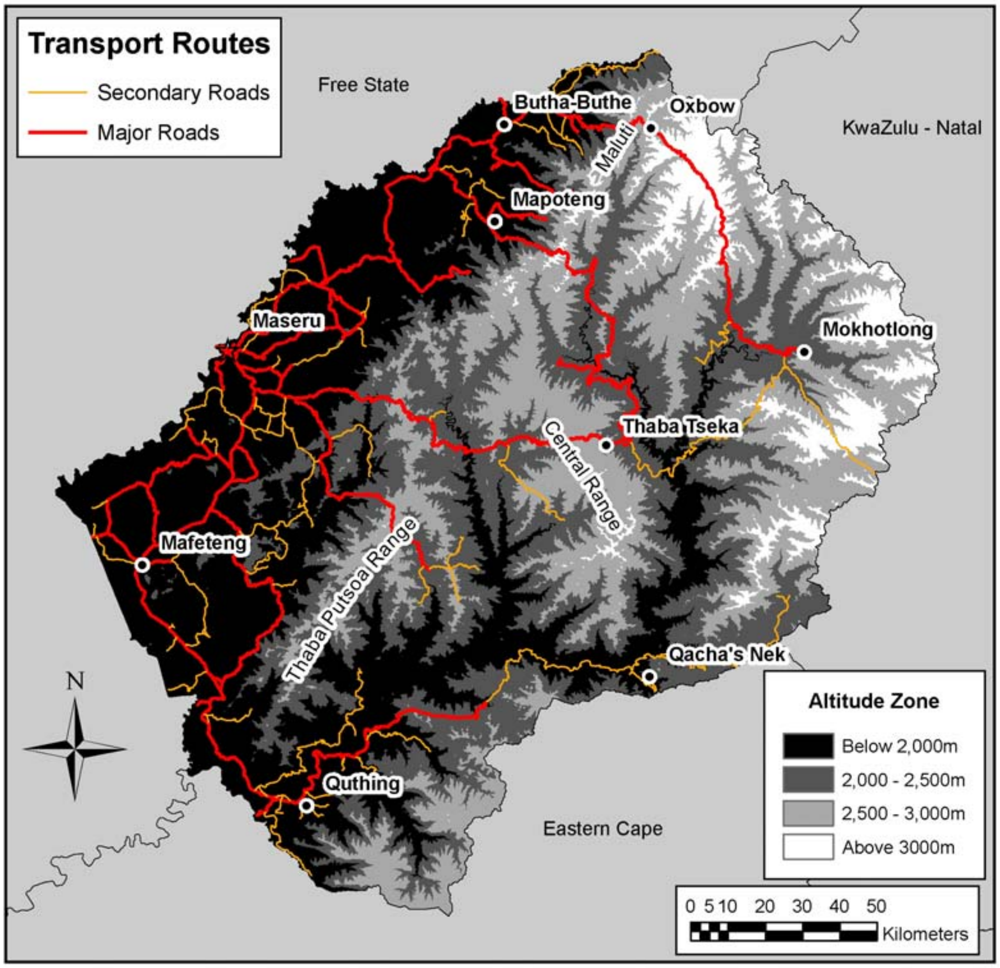

Figure 4.1: Spatial position of transport routes in Lesotho, indicating major and secondary roads.

Two types of road networks have been identified for vulnerability assessment to prolonged snow coverage in Lesotho, major roads and secondary roads. Major roads are tarred or graded surfaces that may be confined to valleys or homogeneous terrain with moderate slope gradient, whilst secondary roads are untarred, ungraded routes that may traverse uneven or heterogeneous terrain. Due to the varying nature of these surfaces, snow cover is assumed to affect each one differently. Secondary roads are assumed to be more susceptible to snow closures than major roads, or may be blocked by snow for longer periods than major roads. It is also assumed that major roads provide quicker and safer access to stricken areas for emergency vehicles. Therefore, the vulnerability of villages to the effects of prolonged snow cover is determined not only by the proximity of transport routes, but also by the type of road.

Separate vector layers of major and secondary roads were digitized from the 1:250 000 topographic map (Section 4.4) using ArcGIS Editor tools. The ArcGIS Spatial Analyst *Distance* tool was then used to construct a raster image with pixel values representing the Euclidean distance from the road vectors for both major and secondary roads. By overlaying the point data from the village database, the Spatial Analyst *Extract Values to Points* tool was used to append the attribute table to include these distance values from major and secondary roads respectively for each village. The digital layer indicating major and secondary roads was converted from a collection of lines to a series of points representing the nodes of each road. Subsequently, the Spatial Analyst *Extract Values to Points* tool was used to create an attribute of snow cover duration at each node of the digital road layer. Therefore, villages could be classified according to the duration of snow cover on the nearest major or secondary road.

4.7 SPOT satellite imagery

The SPOT dataset consists of two distinct snowfall events, with sequential imagery for two study regions in the highlands in northeastern and southwestern Lesotho that correspond to path/row 135/408 and 134/408 of the SPOT orbit track respectively (Figure 4.2). The upper limit of the northeastern study region extends between 28°40'10.229"S; 28°24'09'.951"E and 28°46'24.802"S'; 28°59'09.712"E, with the lower limit ranging from 29°10'43.392"S; 28°15'46.825"E to 29°15'38.614"S; 28°50'4.394"E, and contains sections of the northeastern Drakensberg and the Maluti Range. A total of 111 villages from the settlement database lie within the northeastern study region. The upper limit of the southwestern study region extends between 29°41'28.471"S; 27°29'58.136"E and 29°45'24.159"S; 27°52'47.306"E, with the lower limit ranging from 30°10'5.385"S; 27°22'7.265"E to 30°13'57.309"S; 27°44'45.032"E and contains sections of the Thaba Putsoa Range and the western lowlands. A total of 163 villages from the settlement database lie within the southwestern study region.

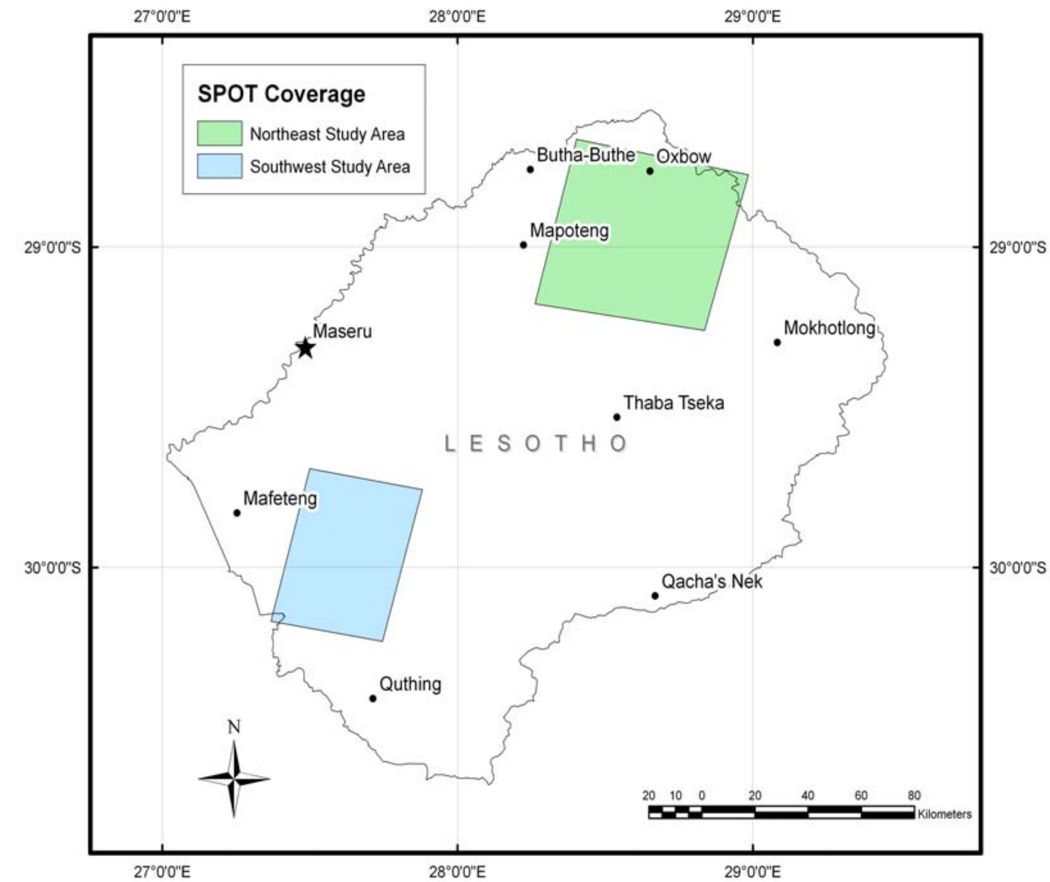

Figure 4.2: Location of the northeastern and southwestern study regions represented by SPOT imagery.

A set of 11 SPOT images with 10m spatial resolution was obtained from the Satellite Application Centre (SAC), South Africa. Three images from the SPOT dataset were captured by the SPOT 1 panchromatic sensor (Table 4.2); five images were from the SPOT 2 platform (Table 4.1), whilst the remaining three images were from the SPOT 4 Mono scanner (Table 4.2). All SPOT images in the dataset consist of a single, sharp panchromatic band. With a pixel size of 10m, SPOT imagery was the most accessible high-resolution remotely sensed data available to the study.

Table 4.1: Description of SPOT scenes for northeastern study region (135/408).

Scene Number	Satellite	Spectral Mode	Path (K)	Row (J)	Date	Bands	Pixel Size
1	SPOT 2	PAN	135	408	17 July 2000	1	10m
2	SPOT 2	PAN	135	408	22 July 2000	1	10m
3	SPOT 2	PAN	135	408	28 July 2000	1	10m
4	SPOT 2	PAN	135	408	01 Aug 2000	1	10m
5	SPOT 2	PAN	135	408	02 Aug 2000	1	10m

Snow in the northeastern study region is recorded over 17 days by images captured on 17th, 22nd and 28th July 2000, and on 1st and 2nd August 2000 (Table 4.1). Two snowfall events are recorded in the southeastern region; the first represents a period of 7 days with images for 4th, 5th and 10th August 1992, while the second event covers a period of 10 days with images recorded on 16th, 21st and 26th July 2000 (Table 4.2). Each study region was spatially refined to include areas common to all images in the entire set of imagery for that region, which enhanced processing efficiency by excluding unnecessary pixels from further analysis. SPOT images were rectified using bilinear interpolation resampling with a cubic polynomial fit, and assigned to Universal Transverse Mercator (UTM) Complex–Zone 35S projection.

Table 4.2: Description of SPOT scenes for southwestern study region (134/410).

Scene Number	Satellite	Spectral Mode	Path (K)	Row (J)	Date	Bands	Pixel Size
1	SPOT 1	PAN	134	410	04 Aug 1992	1	10m
2	SPOT 1	PAN	134	410	05 Aug 1992	1	10m
3	SPOT 1	PAN	134	410	10 Aug 1992	1	10m
4	SPOT 4	PAN	134	410	16 July 2000	1	10m
5	SPOT 4	PAN	134	410	21 July 2000	1	10m
6	SPOT 4	PAN	134	410	26 July 2000	1	10m

4.7.1 SPOT snow cover classification

Supervised classification techniques are one of the tools available to distinguish snow-covered pixels using multi-spectral imagery. In this method, image-processing modules analyze the unique spectral signatures of snow in each spectral band, based on user-selected training sites. However, accurate spectral responses could not be accurately obtained from single-band panchromatic images; so unsupervised classification techniques were employed to classify the SPOT images (Figure 4.3). The process of unsupervised classification involves the automatic grouping of pixels with similar values. The user may manipulate the thresholds on which the final classification of pixels is based, and there are multiple series and configurations of the classification algorithms. The unclassified panchromatic SPOT images had grey values ranging from –255 to +255. Through multiple iterations and extensive refinement of the unsupervised classification process, the optimum grouping of pixels into 20 distinct classes was established. Of these 20 automatically grouped classes, the first 10 classes contained pixels with lower grey values ranging from –255 to +78. Low grey values represent low reflectance, which is characteristic of bare ground, so the first 10 classes were reclassified as 0, or no snow. However, the last 10 classes represented higher grey values (ranging from +78 to +255), caused by the higher reflectance of snow surfaces. Pixels with values between +78 and +255 were therefore reclassified as 1, or snow covered.

4.7.2 Analysis of snow extent

The spatial extent of snow was calculated for each filtered and trimmed SPOT SNOMAP image in square kilometers with ArcGIS Spatial Analyst *Calculate Area* utility. These calculated areas were then related to the topographic elements derived from the DEM by using the Zonal Statistics *Tabulate Area* module. *Tabulate Area* outputs a table of the area (in km^2) contained by each unique value in a classified raster image. Therefore, the *Tabulate Area* module was applied to each SNOMAP image to calculate the extent of snow occurring in specific classes represented by the raster images of altitude (48 classes) and aspect (36 classes). The *Tabulate Area* tool produced data tables for each SNOMAP image containing the areal extent of snow in each topographic setting (altitude and aspect).

4.8 MODIS satellite imagery

The Terra and Aqua spacecraft have local equatorial crossing times of approximately 10:30am and 1:30pm respectively, recording surface information in a 2330km-wide swath. Geometrically corrected MODIS images and data products from the Terra and Aqua satellites are freely available online from the Rapid Response website which provides daily coverage since August 2003: http://rapidfire.sci.gsfc.nasa.gov/subsets/. Available data products include several composites of MODIS bands: 1-4-3 (true colour), 7-2-1, and 3-6-7. True colour composites provide natural-looking images of the land surface and atmosphere, while combinations of bands 7-2-1 and 3-6-7 are valuable for distinguishing snow and ice, as they are highly absorbent in MODIS bands 6 and 7 and very reflective in the visible part of the electromagnetic spectrum. However, daily Aqua or Terra images in the FAS_1 South Africa subset are often subjected to distortion or excessive cloud cover and are therefore unsuitable for snow mapping. Under these circumstances, the daily image from the corresponding satellite provides a clearer view of the Earth's surface, as the extent of cloud cover can change significantly within the 3-hour interval between satellite overpasses (Hall and Riggs, 2007). This allows for more consistent temporal coverage of the study region by including satellite images for snowfall events that would otherwise be excluded from analysis.

Although MODIS Daily Snow Product imagery is freely available, it has a minimum spatial resolution of 500m. These products provide snow cover imagery that is already processed by means of a MODIS snow-product classification algorithm. While MODIS 500m snow cover products are of excellent quality and the ready-processed imagery saves on user processing time, a 500m pixel-size was deemed too coarse for the requirements of the study. Therefore, MODIS Rapid Response imagery was selected on the basis of its 250m spatial resolution.

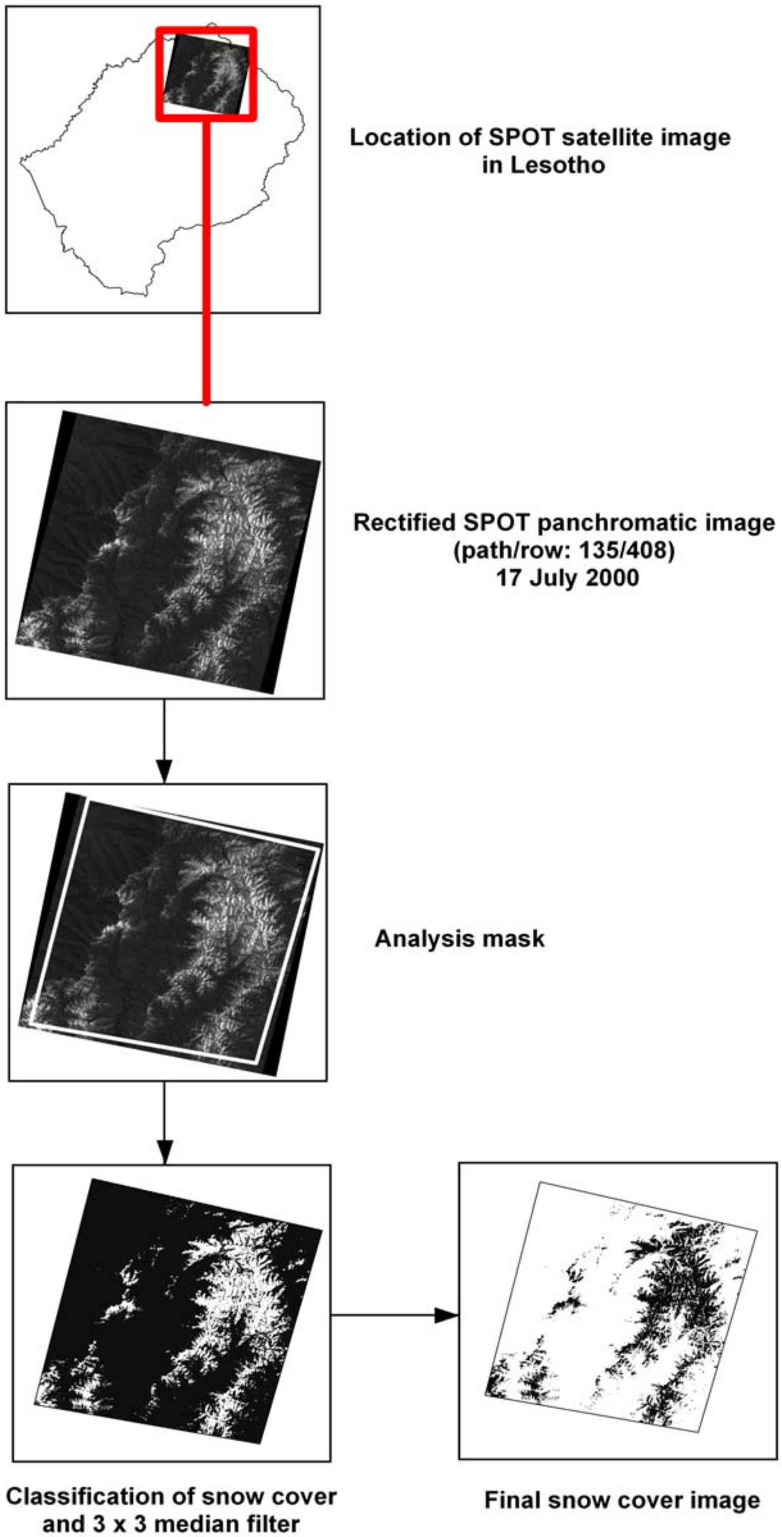

Figure 4.3: The SPOT snow mapping process, using an image from 17 July 2000 as an example.

A total of 189 images from the FAS_1 South Africa subset of NASA's Rapid Response System were downloaded for the purposes of mapping snow extent in Lesotho (Table 4.3). An initial analysis of monthly snowfall frequency and duration was undertaken for snowfalls represented by MODIS imagery. For this study, composite images of 1-4-3 and 7-2-1 band combinations were obtained for each observed occurrence of snow, as bands 4 and 7 are used for deriving snow cover images (Figure 4.4).

Table 4.3: Description of MODIS images used in the study, indicating the date and duration of recorded snowfalls.

Date	Description of event	Duration (Days)
12 August 2003	Isolated, light snowfall on slopes in the southern highlands. No snow on other ranges.	19
14 August 2003		
16 August 2003		
17 August 2003		
19 August 2003		
21 August 2003		
22 August 2003		
23 August 2003		
25 August 2003		
26 August 2003		
27 August 2003		
29 August 2003		
30 August 2003		
11 June 2004	Light, isolated snowfall over the southern highlands. No snow on other ranges.	20
12 June 2004		
14 June 2004		
15 June 2004		
16 June 2004		
17 June 2004		
18 June 2004		
20 June 2004		
01 July 2004	Heavy snowfall on the Maluti Range and Central Range. Snowfall is concentrated on the eastern and north eastern	12
03 July 2004		
04 July 2004		
06 July 2004		

Date	Description of event	Duration (Days)
07 July 2004	highlands.	
08 July 2004		
09 July 2004		
10 July 2004		
12 July 2004		
14 July 2004	Light, isolated snowfall over southern highlands.	12
18 July 2004		
19 July 2004		
21 July 2004		
23 July 2004		
25 July 2004		
29 July 2004	Heavy, widespread snow on all ranges, especially the Maluti Range and north eastern highlands, and along eastern escarpment edge.	11
30 July 2004		
31 July 2004		
01 August 2004		
08 August 2004		
04 and 5th September 2004	Light snowfall over eastern highlands.	2
07 September 2004	Heavy snowfall over Maluti Range, north eastern highlands and eastern escarpment edge, and the Central Range.	10
08 September 2004		
09 September 2004		
10 September 2004		
11 September 2004		
12 September 2004		
13 September 2004		
14 September 2004		
15 September 2004		
16 September 2004		
05 May 2005	Light, isolated snowfall over eastern highlands.	3
06 May 2005		
07 May 2005		
16 May 2005	Light snowfall over Maluti Range, and southern and eastern highlands.	2
17 May 2005		
13 August 2005	Light snowfall over	7

Date	Description of event	Duration (Days)
19 August 2005	northeastern and southern highlands.	
25 May 2006 26 May 2006 27 May 2006 28 May 2006 31 May 2006 01 June 2006 04 June 2006 05 June 2006 06 June 2006 08 June 2006 09 June 2006 10 June 2006 13 June 2006 19 June 2006 20 June 2006	Widespread, heavy snowfall on Maluti Range, Thaba Putsoa Range, northeastern highlands and the escarpment edge. Light snowfall on 10 June 2006.	26
24 June 2006 25 June 2006 26 June 2006 04 July 2006 12 July 2006 13 July 2006	Light snowfall along eastern and southeastern highlands, and escarpment edge.	11
05 August 2006 06 August 2006 07 August 2006 08 August 2006 14 August 2006	Heavy, widespread snowfall on all ranges and along the escarpment.	10
20 August 2006 21 August 2006	Light, widespread snowfall over all ranges.	2
28 September 2006 29 September 2006 30 September 2006 01 October 2006	Isolated, light snowfall over southern highlands.	4
26 May 2007 28 May 2007	Light snowfall on all ranges.	3

Date	Description of event	Duration (Days)
11 June 2007	Widespread snowfall over Maluti Range, Thaba Putsoa Range, and the southeastern and eastern highlands.	15
12 June 2007		
13 June 2007		
15 June 2007		
16 June 2007		
17 June 2007		
18 June 2007		
19 June 2007		
20 June 2007		
21 June 2007		
22 June 2007		
23 June 2007		
24 June 2007		
25 June 2007		
29 June 2007	Heavy snowfall over Maluti Range and eastern highlands, with light snowfall on all other ranges.	2
30 June 2007		
02 July 2007	Widespread, heavy snowfall on the escarpment edge, Maluti Range and southern highlands, with light snowfall on the Central Range and Thaba Putsoa Range.	23
04 July 2007		
07 July 2007		
09 July 2007		
13 July 2007		
14 July 2007		
15 July 2007		
16 July 2007		
17 July 2007		
18 July 2007		
19 July 2007		
20 July 2007		
21 July 2007		
23 July 2007		
24 July 2007		
25 July 2007	Light snowfall over escarpment edge and eastern highlands.	2
26 July 2007		
29 July 2007	Widespread, light snowfall on	9

Date	Description of event	Duration (Days)
30 July 2007	highlands in all ranges.	
31 July 2007		
01 August 2007		
02 August 2007		
03 August 2007		
04 August 2007		
06 August 2007		
08 August 2007	Heavy snowfall over Thaba Putsoa Range and southern highlands.	7
09 August 2007		
10 August 2007		
11 August 2007		
13 August 2007		
14 August 2007		
27 August 2007	Light snowfall over the escarpment edge and southeastern highlands.	6
28 August 2007		
29 August 2007		
30 August 2007		
31 August 2007		
01 September 2007		
23 April 2008	Heavy snowfall on Maluti Range and escarpment edge with isolated snow on the Central Range, melts by 29 April 2008.	2
24 April 2008		
05 May 2008	Light snowfall on Maluti Range, Thaba Putsoa Range and eastern highlands.	3
06 May 2008		
07 May 2008		
05 June 2008	Widespread, heavy snowfall over all ranges and along escarpment edge.	12
10 June 2008		
12 June 2008		
13 June 2008		
14 June 2008		
15 June 2008		
16 June 2008		
22 June 2008	Widespread snowfall over Maluti Range, Central Range	10
23 June 2008		

Date	Description of event	Duration (Days)
24 June 2008	and eastern highlands along the escarpment.	
25 June 2008		
26 June 2008		
28 June 2008		
29 June 2008		
01 July 2008		
10 July 2008	Isolated, light snowfall over southern highlands.	16
11 July 2008		
12 July 2008		
13 July 2008		
14 July 2008		
17 July 2008		
22 July 2008		
24 July 2008		
25 July 2008		
26 July 2008	Light, widespread snowfall over all ranges.	3
28 July 2008		
01 September 2008	Isolated snowfall on eastern highlands.	1
21 September 2008	Heavy snowfall along escarpment edge and Maluti Range.	9
22 September 2008		
23 September 2008		
24 September 2008		
27 September 2008		
28 September 2008		
29 September 2008		
09 June 2009	Light snowfall on northeastern highlands and Maluti Range.	1
26 June 2009	Widespread snowfall over interior and western lowlands.	18
10 July 2009		
11 July 2009		
13 July 2009		
16 July 2009	Light snowfall over eastern highlands and escarpment.	13
18 July 2009		
19 July 2009		
20 July 2009		

Date	Description of event	Duration (Days)
21 July 2009		
25 July 2009		
26 July 2009		
27 July 2009		
28 July 2009		
04 August 2009	Widespread, heavy snowfall over the Maluti Range and escarpment, with light snowfalls over southeastern highlands, Thaba Putsoa Range and Central Range.	25
06 August 2009		
07 August 2009		
11 August 2009		
13 August 2009		
14 August 2009		
16 August 2009		
17 August 2009		
18 August 2009		
21 August 2009		
22 August 2009		
23 August 2009		
24 August 2009		
28 August 2009		
19 June 2010	Heavy snowfall over Thaba Putsoa Range and southern highlands.	3
20 June 2010		
21 June 2010		
22 June 2010		
23 June 2010	Widespread snowfall on northeastern highlands, Maluti Range and Drakensberg escarpment.	4
24 June 2010		
25 June 2010		
26 June 2010		
27 June 2010		
28 June 2010	Light snowfall over eastern highlands and escarpment.	15
29 June 2010		
01 July 2010		
02 July 2010		
13 July 2010		
14 July 2010	Widespread snowfall over all ranges and along escarpment edge.	4
16 July 2010		
17 July 2010		

Date	Description of event	Duration (Days)
18 July 2010		
20 August 2010	Light snowfall over Thaba Putsoa, Maluti and Central Range.	2
21 August 2010		
22 August 2010		
16 October 2010	Light snowfall over southern highlands.	1
17 October 2010		
11 November 2010	Isolated, light snowfall over southwestern highlands and Drakensberg escarpment.	1

4.8.1 MODIS snow classification

Snow-cover research involves high volumes of remotely sensed imagery, which require classification, manipulation, and storage. For this reason, IDRISI Kilimanjaro GIS was used to initiate batch-processing modules that facilitated efficient classification and storage of the MODIS dataset. A malfunction of sensors in band 6 of the Aqua instrument resulted in its replacement by band 7 in the MODIS Aqua algorithm. Although band 4 and 6 are used in Terra snow algorithms, for this analysis band 7 replaced band 6 for both Aqua and Terra to ensure consistency in mapping snow extent. This modification does not impose significant differences in NDSI calculations for two reasons. Firstly, snow has a similar reflectance in MODIS band 6 and 7, and secondly the MODIS sensors aboard Aqua and Terra are virtually identical (Riggs and Hall, 2004). A true-colour composite of bands 1-4-3 and a 7-2-1 band composite was obtained for each occurrence of snow recorded in Lesotho (Figure 4.4).

All images were fitted with Universal Transverse Mercator (UTM) Complex–Zone 35S projection. Band 7 and band 4 were extracted from the 1-4-3 and 7-2-1 composite images for the purpose of calculating NDSI and for fitting the SNOMAP algorithm (Hall *et al.,* 1995). Due to the large number of images, IDRISI Kilimanjaro batch-processing tools were used for assigning reflectance values and fitting NDSI and SNOMAP criteria. After being converted from digital numbers to reflectance values, the single band 4 and band 7 images were incorporated into a Normalized Difference Snow Index, where:

NDSI = (Band 4 – Band 7) / (Band 4 + Band 7)

Pixels were mapped as snow-covered if the NDSI ≥ 0.4. However, an additional test for snow is required when using the SNOMAP snow-mapping algorithm after the NDSI has been calculated. Following the SNOMAP methodology, pixels were mapped as snow-covered if the reflectance of band 4 was >11% (Hall *et al.,* 1995). The resulting SNOMAP images are Boolean, where snow-covered pixels have a value of 1 and non-snow-covered pixels have values of 0 (Figure 4.4). Finally, SNOMAP images are smoothed by means of a 3×3 median filter, and then spatially clipped to exclude pixels outside Lesotho.

4.8.2 Analysis of snow extent

The spatial extent of snow was calculated for each filtered and trimmed MODIS SNOMAP image in square kilometers with ArcGIS Spatial Analyst *Calculate Area* utility. These calculated areas were then related to the topographic elements derived from the DEM by using the Zonal Statistics *Tabulate Area* module. *Tabulate Area* outputs a table of the area contained by each unique value in a classified raster image. Therefore, the *Tabulate Area* module was applied to each SNOMAP image to calculate the extent of snow occurring in specific classes represented by the raster images of altitude (48 classes) and aspect (36 classes). The *Tabulate Area* tool produced data tables for each SNOMAP image containing the areal extent of snow in each topographic setting.

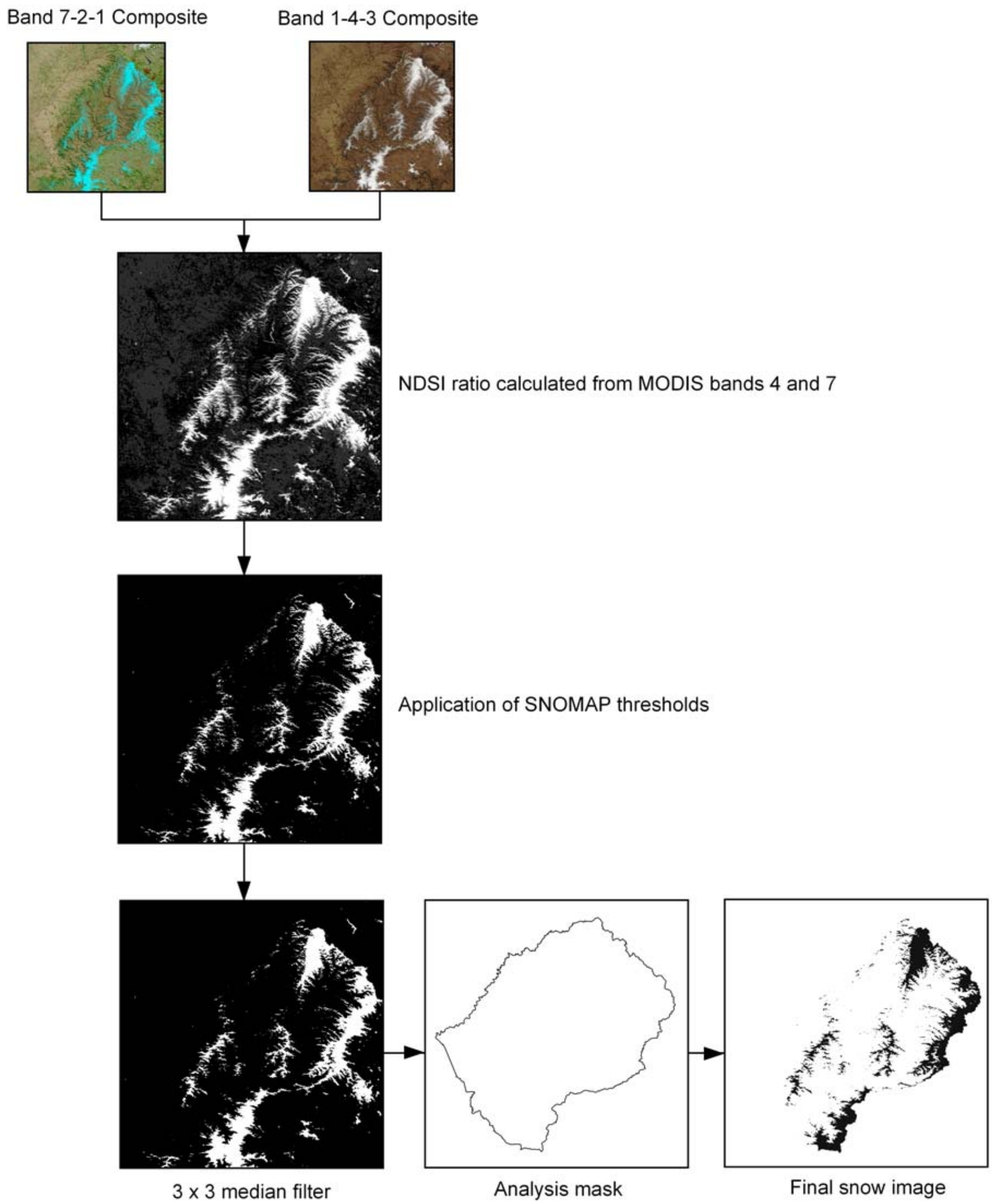

Figure 4.4: The MODIS snow mapping process, using an image from 04 August 2004 as an example.

MODIS images from 2003 to 2010 are compared within and between years in terms of frequency, spatial extent, and topographic controls of snowfalls and snow cover. The relationships between melt rates and altitude and slope aspect are explored, and correlations between mean daily melt rates and mean daily temperatures are analyzed.

4.9 Supplementary Landsat data

MODIS Rapid Response imagery is only available from 2003 onwards; therefore additional data were required to extend the record of snowfall frequency in Lesotho. Whilst the limitations of the Landsat instrument have been discussed, the satellite has been in operation for several decades and is thus a potential source of snow cover data. However, the costs of obtaining multiple high-resolution Landsat imagery are prohibitive, therefore low-resolution browse images have been analyzed visually to provide an indication of the seasonal timing of snowfalls and the general extent of snow cover between 1989 and 2002 (Table 4.4). Such images have been used to explore general seasonal trends of snowfall frequency in Lesotho, due to the lack of other sources of snow cover data (Mulder, 2007). However, the coarse-resolution of such imagery precludes it from GIS and remote sensing analysis, especially in conjunction with DEMs. Further, the duration of snowfall is difficult to determine due to the 16-day interval between Landsat overpasses. Ultimately, Landsat low-resolution images have limited potential for mapping temporal changes of snow cover, although they may provide generalized snowfall frequency information.

Table 4.4: Timing and description of snowfalls derived from low-resolution Landsat images.

Date	Description of Event	Duration (Days)
31 July 1989 16 August 1989	Light, isolated snowfall over Drakensberg escarpment.	16
03 August 1990 19 August 1990	Localized snowfall over Maluti Range.	16
04 September 1990	Light, isolated snowfall over Drakensberg escarpment.	Unknown
22 October 1990	Heavy snowfall over southeastern Drakensberg	Unknown

Date	Description of Event	Duration (Days)
	escarpment.	
19 June 1991	Heavy snowfall over Maluti Range and southeastern highlands.	Unknown
08 August 1992	Heavy, isolated snowfall over Maluti Range.	Unknown
08 June 1993	Isolated, light snowfall over Maluti Range.	Unknown
24 April 1994	Light snowfall over southeastern Drakensberg escarpment.	Unknown
29 July 1994	Heavy, widespread snowfall.	Unknown
30 August 1994	Light, isolated snowfall over southeastern Drakensberg escarpment.	Unknown
30 June 1995	Light, isolated snowfall over southeastern Drakensberg escarpment.	Unknown
18 September 1995	Light, isolated snowfall over southeastern Drakensberg escarpment.	Unknown
20 October 1995	Light, isolated snowfall over southeastern Drakensberg escarpment and Maluti Range.	Unknown
31 May 1996	Extremely light snowfall on northeastern escarpment.	Unknown
18 July 1996	Heavy, widespread snowfall.	Unknown
19 August 1996	Heavy, widespread snowfall.	Unknown
20 September 1996	Light, isolated snowfall over eastern Drakensberg escarpment.	Unknown
06 October 1996	Light, isolated snowfall over eastern Drakensberg escarpment.	Unknown
05 May 1997	Widespread snowfall over Drakensberg escarpment.	Unknown
21 July 1997	Widespread snowfall over Drakensberg escarpment.	Unknown
22 August 1997	Light, widespread snowfall over Drakensberg escarpment.	Unknown
25 August 1998	Heavy, widespread snowfall.	Unknown
12 August 1999	Extremely light snowfall on eastern Drakensberg escarpment.	Unknown
10 May 2000	Light, isolated snowfall over eastern Drakensberg escarpment.	Unknown
30 June 2001	Heavy, widespread snowfall.	Unknown
09 August 2001	Extremely light snowfall on southeastern highlands.	Unknown
10 September 2001	Extremely light snowfall on northeastern and	Unknown

Date	Description of Event	Duration (Days)
	southeastern highlands.	
08 May 2002	Heavy, widespread snowfall.	Unknown
24 May 2002	Heavy, widespread snowfall.	Unknown
09 June 2002	Light, widespread snowfall over Drakensberg escarpment.	Unknown
25 June 2002 11 July 2002	Heavy, widespread snowfall.	16
27 July 2002 12 August 2002	Heavy, widespread snowfall.	16
13 September 2002	Extremely light snowfall on eastern Drakensberg escarpment.	Unknown

4.10 Vulnerability analysis

The vulnerability of villages in Lesotho to prolonged snow cover is calculated by analyzing the spatial location of villages in relation to seasonal snow cover. GIS technology is critical for constructing hazard and vulnerability maps, as it facilitates the analysis of multiple variables based on their location in time and space. Further, data visualization provided by GIS software is valuable for simple, yet rapid identification of key risk areas. The input variables for this vulnerability analysis are the village database, snow cover duration maps and the database of major and secondary roads. Villages were ranked according to their individual vulnerability to prolonged snow cover and proximity to transport routes.

4.10.1 Snow cover duration

The total duration of snow cover derived from SPOT and MODIS SNOMAP images was calculated using the Cell Statistics module in Spatial Analyst Tools, with the sum overlay statistic. Snow duration maps were created for early, mid and late season snowfall events. Each output image represents the spatial extent of each recorded snow occurrence, with each pixel value representing the total duration, in days, of each snowfall event represented by SNOMAP images. The Spatial Analyst *Extract*

Values to Points was used to append the attribute table of the village layer to include a snow duration value from the summed SNOMAP images. Villages were ranked according to the mean number of consecutive days of snow cover (Table 4.5) and the maximum number of consecutive days of snow cover for the period 2003 – 2010 (Table 4.6). The duration of snow cover was compared to altitude and aspect of each pixel. MODIS and SPOT snow duration images were compared to the topographic elements derived from the original DEM by using the *Combine* tool, which assigns a unique output value to each unique combination of input values.

Table 4.5: Mean number of consecutive days of snow cover per annum and associated ranking.

Consecutive days of snow cover	Ranking
0.5 day	1
1 day	2
1.5 days	3
2 days	4
2.5 days	5
3 days	6
3.5 days	7
4 days	8

Table 4.6: Maximum number of consecutive days of snow cover per annum and associated ranking.

Consecutive days of snow cover	Ranking
1 day	1
2 days	2
3 days	3
4 days	4
5 days	5
6 days	6
7 days	7
8 days	8

4.10.2 Proximity and accessibility of transport routes

Road proximity was calculated using the ArcGIS Spatial Analyst *Distance* tool, which appended the attribute table of the village database to include variables for each village based on its distance in kilometers from the nearest major and secondary road. Subsequently, each village received a single rank according to its distance from the nearest type of road (major or secondary). However, it is assumed that secondary roads are more susceptible to being inaccessible as a result of prolonged snow cover. Therefore, if the nearest road to a village was a secondary road, the village was ranked 1 value higher than if the nearest road was a major road (Table 4.7). Further, all villages were ranked according to the mean number of consecutive days of snow cover per annum and the maximum number of consecutive days of snow cover on the nearest road for the period 2003 – 2010. Villages were also ranked according to the duration of snow cover on the nearest major or secondary road, using rank values of one to seven indicating increasing susceptibility to being inaccessible (Table 4.8).

Table 4.7: Proximity of villages to the nearest road and the corresponding vulnerability rank value.

Distance to Nearest Road	Rank Value (if major road)	Rank Value (if secondary road)
0-4.25 km	1	2
4.25-8.5 km	2	3
8.5-12.75 km	3	4
12.75–17 km	4	5
17-21.25 km	5	6
21.25-25.5 km	6	7
25.5-29.75 km	7	8
29.75-34 km	8	9

Table 4.8: Mean number of consecutive days of snow cover per annum on the nearest road and associated rank values.

Consecutive days of snow cover	Rank Value
0.5 day	1
1 day	2
1.5 days	3
2 days	4
2.5 days	5
3 days	6
3.5 days	7
4 days	8

Table 4.9: Maximum number of consecutive days of snow cover on the nearest road for the period 2003 – 2010 and the corresponding vulnerability rank value.

Duration of snow on snow-covered road	Rank Value
1 day	1
2 days	2
3 days	3
4 days	4
5 days	5
6 days	6
7 days	7
8 days	8

4.10.3 Overall vulnerability

For the purposes of this research, the vulnerability of villages to negative impacts associated with prolonged snow cover is a factor of the duration of snow cover, proximity to roads and duration of snow cover on the nearest roads. Each of these vulnerability indicators is expressed using ranking systems indicating increasing levels of risk. Therefore, an overall vulnerability rank may be calculated for each village by simply adding the rank values assigned for the respective vulnerability indicators. The rankings for each of the 5 vulnerability indicators (mean consecutive days of snow cover per annum, maximum consecutive days of snow cover, proximity to roads and mean and maximum consecutive days of snow cover on roads) is expressed on a scale of 0 – 8, therefore the overall vulnerability for each village, expressed as the sum of these rankings, is a ranking on a scale of 0 – 40. Summaries of the vulnerability ranking frequency were created for each of the 10 provinces of Lesotho. Finally, the spatial location of each village was linked to its associated vulnerability index using ArcGIS software, with villages depicted by graduated colours that symbolize the individual vulnerability to negative impacts associated with prolonged snow cover.

5. RESULTS

5.1 Introduction

Remote sensing techniques have been applied to a series of MODIS and SPOT satellite images to analyze trends of snow cover and snow dissipation in Lesotho. Long-term snow frequency patterns are derived from a combination of MODIS images and low-resolution Landsat browse images. Snow cover maps are draped upon a high-resolution DEM to investigate the effects of altitude, aspect and slope gradient on snow distribution. Annual and seasonal trends in snow cover variability are examined statistically, and the mean rate of daily snowmelt and snowfall extent are analyzed in comparison with mean day-time and nocturnal temperature data from Sani Pass on the Drakensberg escarpment. The extent and duration of snow cover is compared between different years, seasons and topographic settings. Finally, a ranking system is applied to villages in Lesotho according to their vulnerability to extended periods of snow coverage. These rankings are based on the seasonal duration of snow cover in villages, and the proximity and accessibility to roads. Spatial patterns of vulnerability are investigated by means of a GIS, and the detailed list of individual vulnerability rankings for each village is included in Appendix 1. Further, detailed regional vulnerability maps are presented in Appendix 2.

5.2 Analysis of SPOT satellite Images

Results are presented from a series of SPOT images representing two study regions from northeastern and southwestern Lesotho. Snow maps are presented for each study area, and the extent and melt rates in each region are analysed according to altitude and slope aspect. However, due to the 1 – 4 day interval between SPOT overpasses, sequential daily imagery of snow events in Lesotho is rare. The presence of clouds or smoke further decreases the number of available images. Nevertheless, a suitable series of images was obtained for a snowfall event in the southwestern highlands during August 1992. An additional series of sequential images was obtained for a snowfall event in the northeastern and southwestern highlands of Lesotho during July 2000. Whilst the SPOT imagery used in this analysis represents relatively small subsets of Lesotho, the high spatial resolution of the data enables the dynamics of snowfall and snow dissipation to be explored at a fine scale.

In the southwestern study region, a mid season snowfall occurred on 4 August 1992 and resulted in an initial snow extent of 345.63 km^2. The highest proportion of snow cover (74 km^2) occurred at 2450m a.s.l and the entire snowfall was limited to altitudes below 2900m a.s.l (Figure 5.1). One day after the snowfall, SCA had decreased to 227.3 km^2 then to 124.6 km^2 six days after the snowfall (Figure 5.3). Thus, initial snow cover decreased by 22.6%/day, but decreased to an average of only 7%/day over the next six days after the snowfall (Figure 5.3). Temperature data from Lesotho were unavailable for the 4 August 1992 event, thus snow cover depletion and mean daily melt could not be compared with mean daily and nocturnal temperatures. Given the absence of further available SPOT images post-dating the snowfall event, the date by which all snow had ablated is unknown.

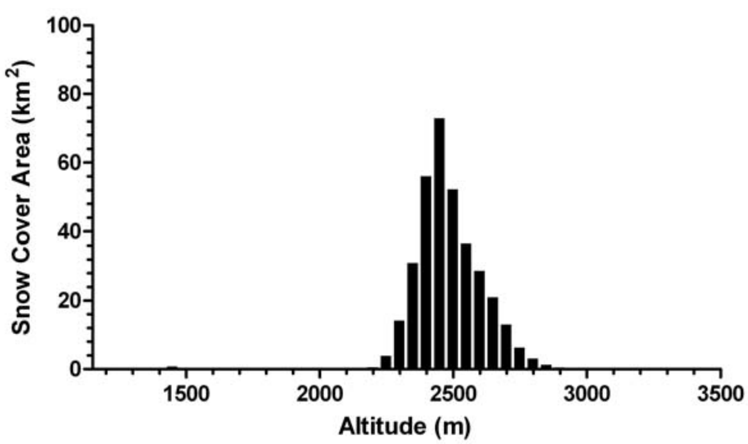

Figure 5.1: Altitudinal zones and snow cover area for the snowfall on 4 August 1992.

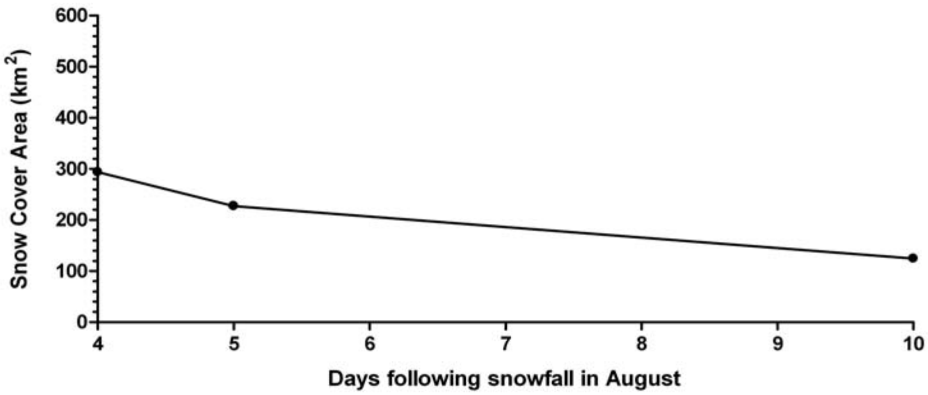

Figure 5.2: Snow cover area for the southwestern study region for the period 4 – 10 August 1992.

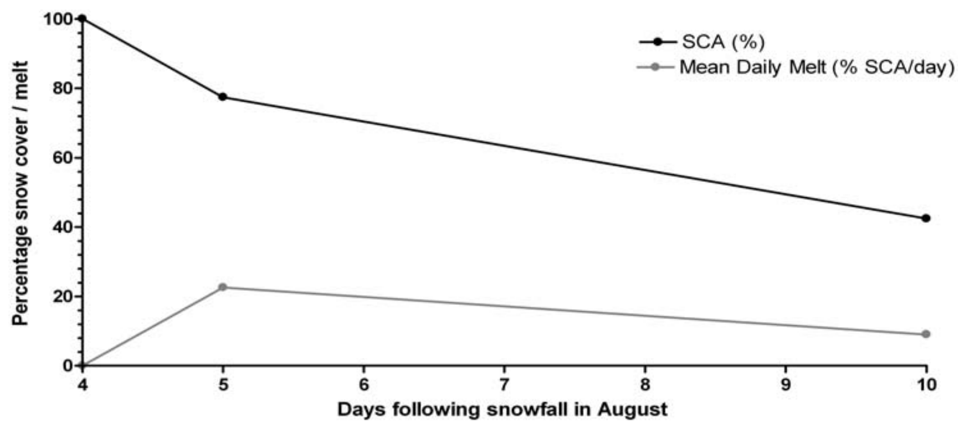

Figure 5.3: Relationship between SCA and snowmelt for the southwestern study region from 4 – 10 August 1992.

The snowfall event that occurred on 16 July 2000 resulted in widespread snow cover at high altitudes throughout Lesotho. Due to the timing of this event, it may be classified as a mid season snowfall (Mulder and Grab, 2009). However, SPOT imagery for the northeastern study region was only available from 17 July 2000. SCA in the northeastern study region totaled 528.4 km^2 and lasted for 16 days with the majority of snow cover (97 km^2) occurring between 3050m a.s.l and 3100m a.s.l (Figure 5.4).

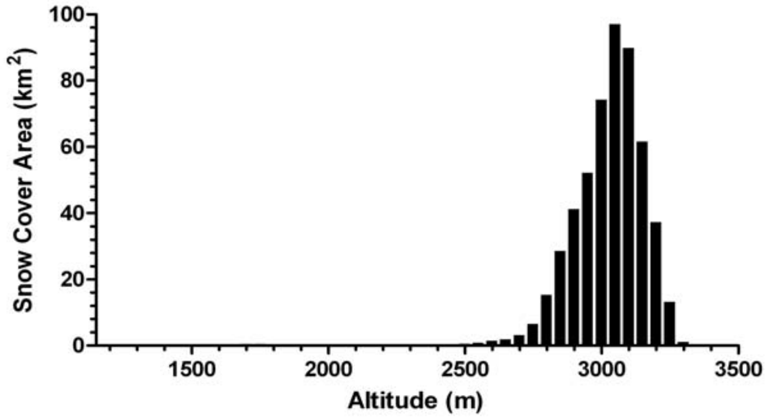

Figure 5.4: Altitudinal zones and snow cover area in the northeastern study region for the snowfall on 16 July 2000.

The SPOT image sequence for the southwestern study region begins on 16 July 2000, the day of the original snowfall. Whilst the majority of snow cover (76 km^2) occurs at 2450m a.s.l (Figure 5.5), the initial snow covered area (506.8 km^2) decreases to 25.7 km^2 five days after the snowfall, and 7.0 km^2 ten days after the snowfall (Figure 5.6). Snow cover in the northeastern study region is concentrated at high altitude above 3050m a.s.l, yet is spread over lower altitudes (2450m a.s.l) in the southwestern study region. Because air temperatures decrease considerably with altitude, snow cover exhibits a slower rate of melt in the northeastern study region than the southwestern study region, which has a lower mean altitude (Figure 5.6).

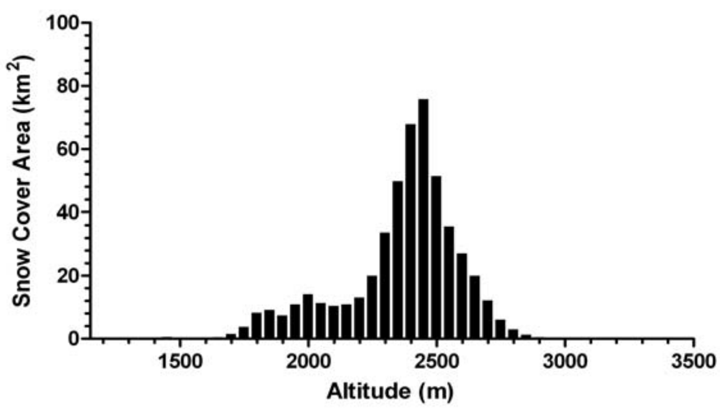

Figure 5.5: Altitudinal zones and snow cover area in the southwestern study region for the snowfall on 16 July 2000.

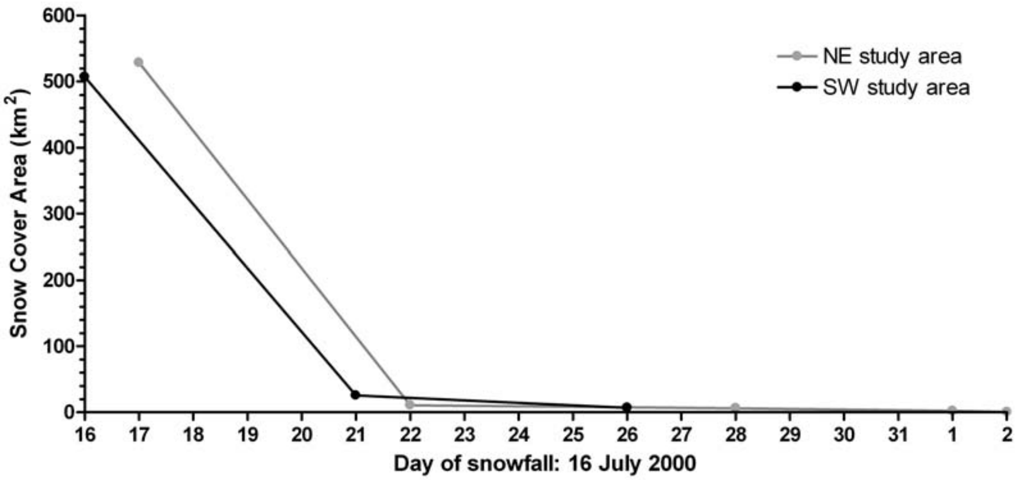

Figure 5.6: SCA for northeastern and southwestern study regions during July 2000.

5.2.1 Snowmelt and temperature

The mean daytime and nocturnal temperatures were calculated from hourly data recorded at an automatic weather station on the escarpment near Sani Pass, but may not reflect actual temperatures across the entire landscape (See Section 4.3 for the precise location and specifications of the weather station). An analysis of the mean daily and nocturnal temperatures for Lesotho during the July 2000 snowfall event reveals a relatively high rate of mean daily melt (19.6%/day) and low remaining SCA (2.1%) five days after the initial snowfall in the northeastern study region, coinciding with relatively high day-time temperatures (averaging 2.1°C) (Figure 5.7). However, six to eight days after the snowfall, day-time and nocturnal temperatures considerably decrease respectively to on average –7°C and –12°C. Consequently, the rate of mean daily melt declined to 7.1%/day on the tenth day after the snowfall. Mean day-time temperatures remained below 5°C for the remainder of the 15-day period, with 1% of the original SCA remaining. Ten to fifteen days after the snowfall, an increase in day-time temperature to on average 4.5°C coincides with a considerable increase in mean daily melt to a maximum of 73.3% on the fifteenth day after the snowfall (Figure 5.7). The mean rate of snowmelt for the northeastern study region was 23.18%/day, however snowmelt exhibited considerable variability over the 16-day period (Table 5.1). Whilst a positive correlation existed between the rate of mean daily snowmelt and mean air temperatures, the high *P* values indicate that the relationships are not statistically significant (Table 5.1).

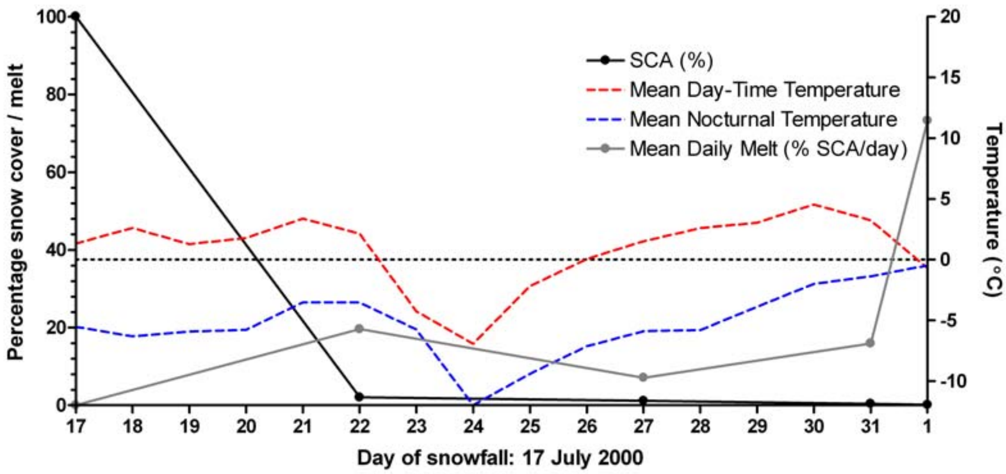

Figure 5.7: Relationship between SCA, snowmelt and temperature for the northeastern study region from 17 July - 2 August 2000.

Table 5.1: Statistical relationships between mean day-time and nocturnal temperatures and mean daily snowmelt rates derived from SPOT imagery.

		SW Study Region	NE Study Region
	Mean	11.18 %/day	23.18 %/day
	Median	14.55 %/day	15.95 %/day
	Standard Deviation	9.93 %/day	29.02 %/day
	Minimum	0.00 %/day	0.00 %/day
	Maximum	18.98 %/day	73.27 %/day
Correlation with mean day-time temperatures	r^2 **value**	0.84	0.52
	P **value**	0.26	0.17
Correlation with mean nocturnal temperatures	r^2 **value**	0.59	0.62
	P **value**	0.44	0.11

An examination of the mean day-time and nocturnal temperatures for Lesotho for the same snowfall event in the southwestern study region reveals a rapid rate of mean daily melt (average of 18.9%/day) and low remaining SCA (5.0%) coinciding with positive mean day-time temperatures (3.4°C) over the first five days following the initial snow covered image (Figure 5.8). Five to ten days after the snowfall, mean daytime and nocturnal temperatures decreased considerably to –7°C and –12°C respectively, whilst the rate of mean daily melt and remaining SCA decreased only slightly for the same period (Figure 5.8). Whilst a positive correlation existed between the rate of mean daily snowmelt and mean air temperatures, the high *P* values indicate that the relationships are not statistically significant (Table 5.1).

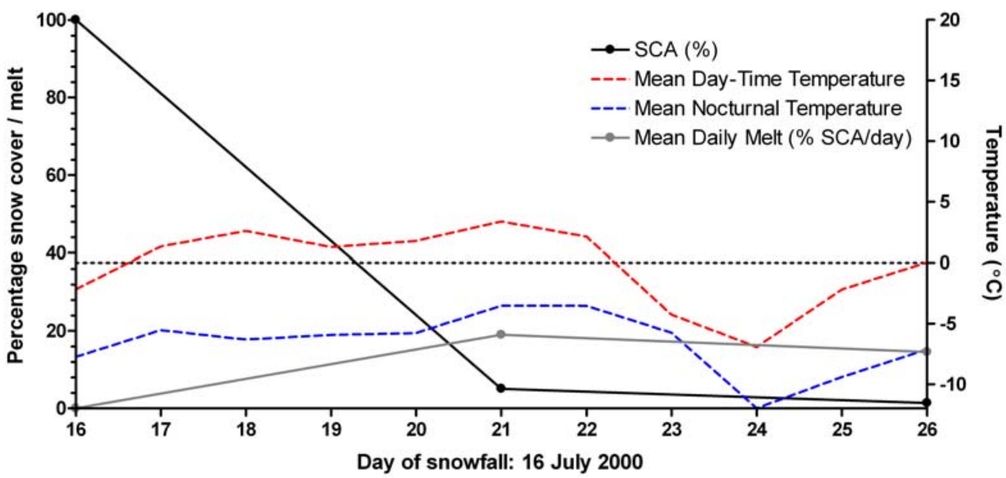

Figure 5.8: Relationship between SCA, snowmelt and temperature for the southwestern study region from 16 - 26 July 2000.

5.2.2 Snowmelt and topography

The mean rate of daily snowmelt for snowfalls in the southwestern and northeastern study regions is analyzed according to altitude and aspect. The snow cover recorded for the southwestern study region using SPOT images in 1992, exhibited a relatively low mean rate of melt of below 20%/day at all altitudes (Figure 5.9). However, the rate of snowmelt decreases to a minimum of below 1%/day at 2450m a.s.l, before increasing to an average of 20%/day between 2450m a.s.l and 2950m a.s.l. A comparison of mean daily snowmelt rates and altitude indicates that the mean rate of melt was 11.02%/day at all altitudes in the southwestern study region in 1992 (**Error! Reference source not found.**). When comparing slope aspects, the mean daily snowmelt rate has a mean of 11.39%/day on all slope aspects (**Error! Reference source not found.**). The snowfall recorded in the northeastern study region melted at an average rate of 46%/day between 1650m a.s.l and 1750m a.s.l (Figure 5.9). No snowmelt data was recorded between 1750m a.s.l and 2750m a.s.l, where snow dissipated by 44%/day. However, this rate decreased to 19%/day at 3000m a.s.l. Subsequently, snow dissipation increased to a maximum rate of 48%/day at an altitude of 3300m a.s.l (Figure 5.9). The rate of daily snowmelt rate is highest on average at all altitudes in the southwestern study region after the July 2000 snowfall with a mean of 12.27%/day (**Error! Reference source not found.**). Snow cover in the northeastern and southwestern study region melts faster on north-facing slopes (50%/day and 20%/day respectively) than on south-facing slopes (20%/day and 4%/day respectively) (Figure 5.10). The mean rate of melt in the southwestern study region for the 1992 snowfall is similar to the snowfall recorded during 2000, at all aspects. When comparing slope aspects, the southwestern study region exhibits the lowest mean rate of melt (11.39%/day) on all aspects after the August 1992 snowfall (**Error! Reference source not found.**).

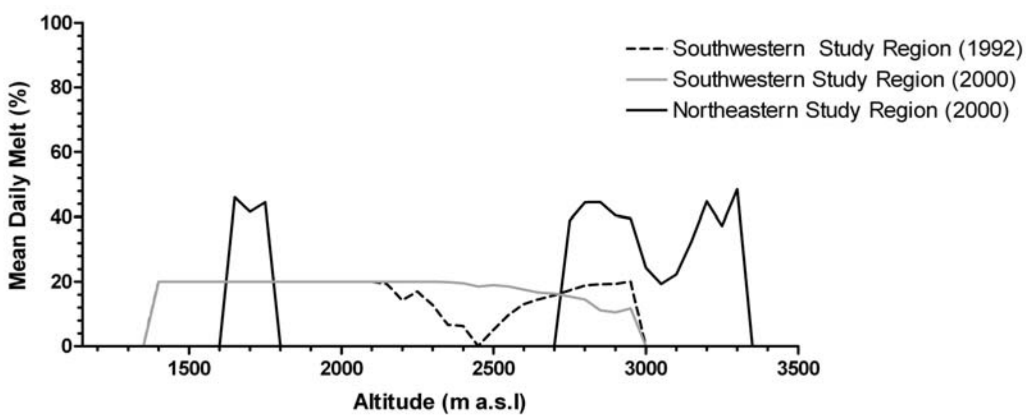

Figure 5.9: Relationship between snowmelt and altitude based on SPOT imagery.

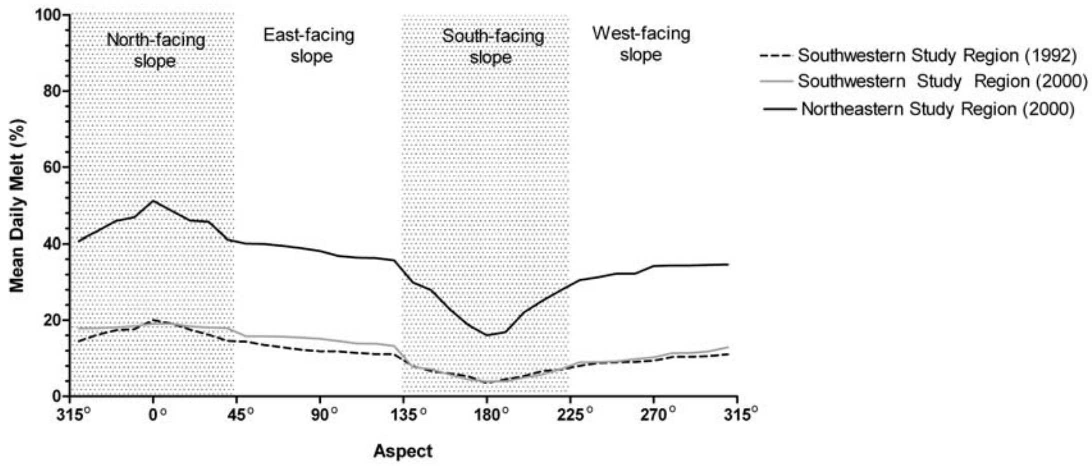

Figure 5.10: Relationship between snowmelt and aspect based on SPOT imagery.

Table 5.2: Statistical summary of mean daily snowmelt rates based on SPOT imagery for specific aspects.

	Northeastern Study Region					**Southwestern Study Region**				
Aspect	Mean	Median	Standard Deviation	Min	Max	Mean	Median	Standard Deviation	Min	Max
North-facing	14.05	0.79	27.05	0.00	54.62	9.04	3.37	13.85	0.00	29.40
East-facing	6.69	0.09	13.26	0.00	26.59	8.88	3.17	13.78	0.00	29.15
South-facing	5.06	0.22	9.82	0.00	19.79	4.98	1.71	7.74	0.00	16.49
West-facing	8.56	0.49	16.46	0.00	33.25	6.49	2.40	9.87	0.00	21.16

Table 5.3: Statistical summary of mean daily snowmelt rates based on SPOT imagery for specific altitudinal zones.

	Northeastern Study Region					Southwestern Study Region				
Altitude Zone	Mean	Median	Standard Deviation	Minimum	Maximum	Mean	Median	Standard Deviation	Minimum	Maximum
1100-1200m a.s.l	-	-	-	-	-	-	-	-	-	-
1200-1300m a.s.l	-	-	-	-	-	-	-	-	-	-
1300-1400m a.s.l	-	-	-	-	-	-	-	-	-	-
1400-1500m a.s.l	-	-	-	-	-	0.20	0.07	0.31	0	0.66
1500-1600m a.s.l	-	-	-	-	-	0.13	0.03	0.22	0	0.47
1600-1700m a.s.l	0.01	0	0.02	0	0.03	0.16	0.06	0.24	0	0.50
1700-1800m a.s.l	0.04	0	0.09	0	0.17	0.42	0.31	0.51	0	1.05
1800-1900m a.s.l	0	0	0.01	0	0.02	0.93	0.13	1.69	0	3.46
1900-2000m a.s.l	-	-	-	-	-	0.98	0.12	1.79	0	3.66
2000-2100m a.s.l	-	-	-	-	-	1.43	0.31	2.45	0	5.07
2100-2200m a.s.l	-	-	-	-	-	1.21	0.29	2.05	0	4.26
2200-2300m a.s.l	-	-	-	-	-	2.64	1.99	3.18	0	6.60
2300-2400m a.s.l	0	0	0.01	0	0.01	11.76	9.81	12.64	0.07	27.36
2400-2500m a.s.l	0.02	0	0.04	0	0.08	22.57	18.13	23.04	1.11	52.92
2500-2600m a.s.l	0.07	0	0.13	0	0.27	14.89	10.62	16.45	0.83	37.50
2600-2700m a.s.l	0.16	0	0.33	0	0.65	7.99	4.75	9.58	0.98	21.49
2700-2800m a.s.l	0.48	0	0.96	0	1.92	2.96	1.62	3.73	0.31	8.30
2800-2900m a.s.l	2.19	0.02	4.36	0	8.73	0.52	0.28	0.68	0.02	1.51
2900-3000m a.s.l	4.67	0.12	9.18	0	18.44	0.03	0.02	0.04	0	0.09
3000-3100m a.s.l	8.61	0.38	16.71	0	33.67	-	-	-	-	-
3100-3200m a.s.l	7.57	0.36	14.67	0	29.58	-	-	-	-	-
3200-3300m a.s.l	2.52	0.17	4.82	0	9.75	-	-	-	-	-
3300-3400m a.s.l	0.05	0	0.10	0	0.20	-	-	-	-	-
>3400m a.s.l	-	-	-	-	-	-	-	-	-	-

5.3 Analysis of MODIS satellite Images

The MODIS Rapid Response system, developed in 2003, provides near- realtime data with a pixel resolution of 250m, available on the Internet. Although a daily record of snowfalls for the period 2003 – 2010 has been obtained from the Rapid Response project, the investigation of long-term snowfall frequency required data for a longer period. Therefore, Landsat browse images from similar snowfall research on the Drakensberg escarpment (Mulder, 2007) for the period 1989 – 2002 were included in the analysis of snowfall frequency. However, the Landsat low-resolution images were unsuitable for the application of remote sensing techniques. Further, Landsat imagery is unsuitable for daily snow mapping applications due to the 16-day intervals between satellite overpasses. Therefore, the monthly snowfall frequencies derived from Landsat browse images are likely to underestimate the number of annual and monthly snowfalls. However, these Landsat data represent the only available information regarding snowfalls in Lesotho prior to 2003, and are thus included in the analysis of monthly and annual snowfall frequencies in addition to MODIS Rapid Response imagery.

5.3.1 Snowfall frequency

A comparison of annual snowfall frequencies derived from Landsat browse imagery indicates high variability in the number and timing of snowfalls (Standard Deviation = 2.02) (Table 5.4). One snowfall was recorded each year for 1991 – 1993 (Figure 5.11), and 1998 – 2000 (Figure 5.12), whilst 5 snowfalls were recorded in 1996 and 8 were recorded in 2002. Such high variability may be due to the 16-day interval between Landsat overpasses, and thus it is likely that several snowfalls may not be represented by such imagery. MODIS data is a considerably more accurate source of daily snowfall measurements. The examination of the monthly frequency of snowfalls in Lesotho during the seven-year period between 2003 and 2010 reveals high interannual variability (Standard Deviation = 2.56) in the number and timing of snowfalls recorded by the MODIS instrument (Table 5.4). The highest frequency occurred in 2007 and 2008, with eight snowfall events recorded between the months of April and September for each year, whilst only one snowfall in August was recorded during 2003 (Figure 5.13).

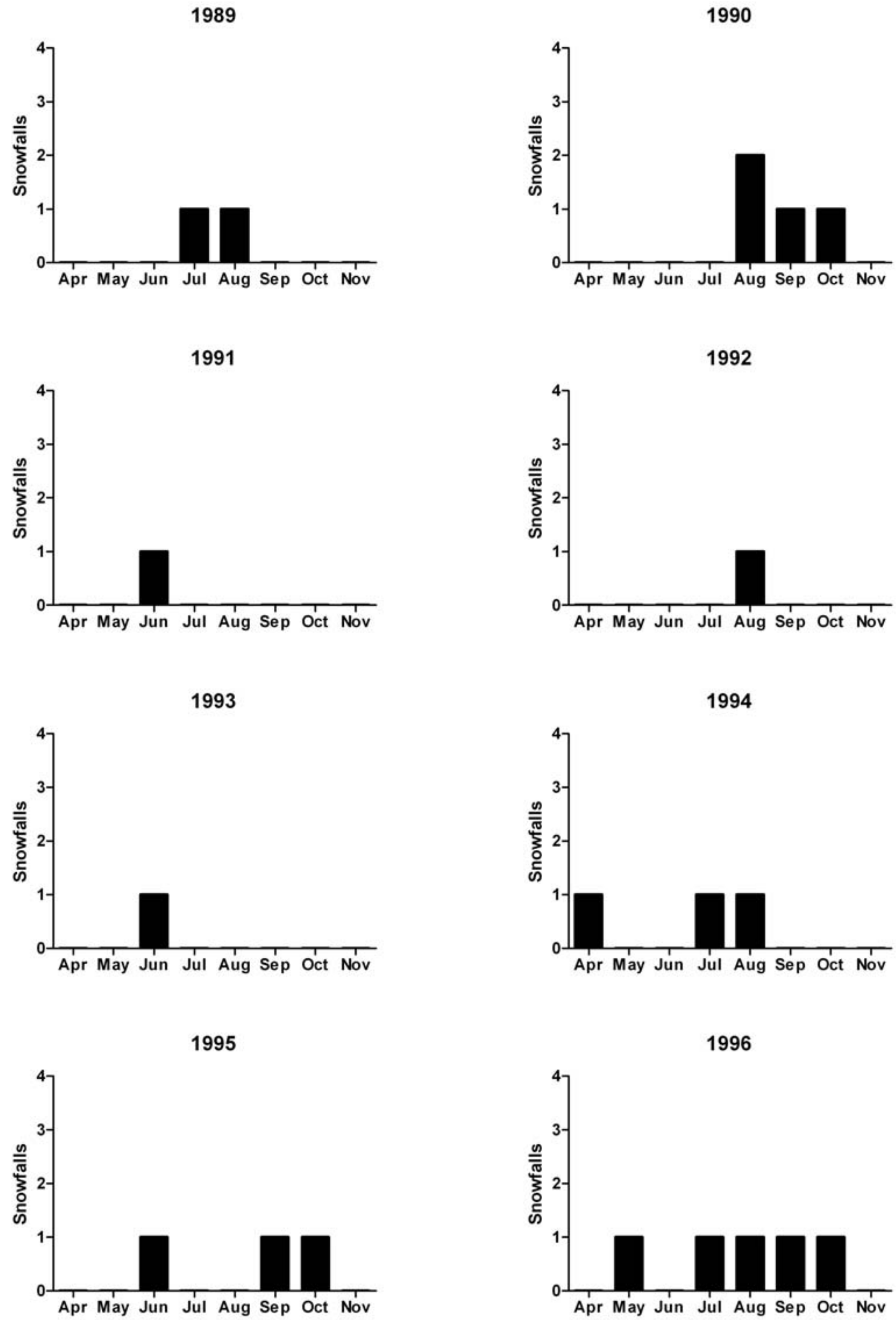

Figure 5.11: Landsat monthly snowfall frequency for the period 1989 – 1996.

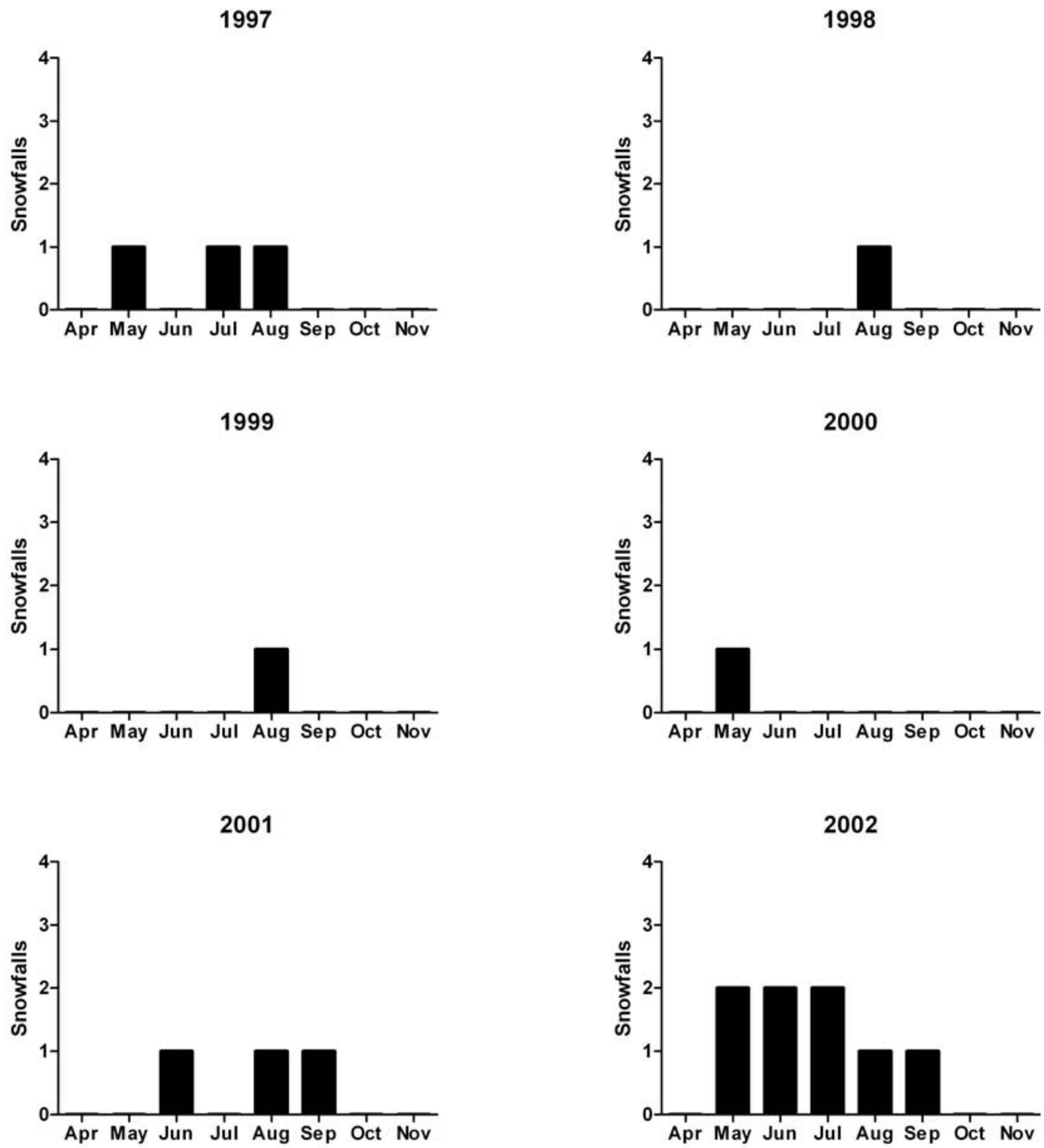

Figure 5.12: Landsat monthly snowfall frequency for the period 1997 – 2002.

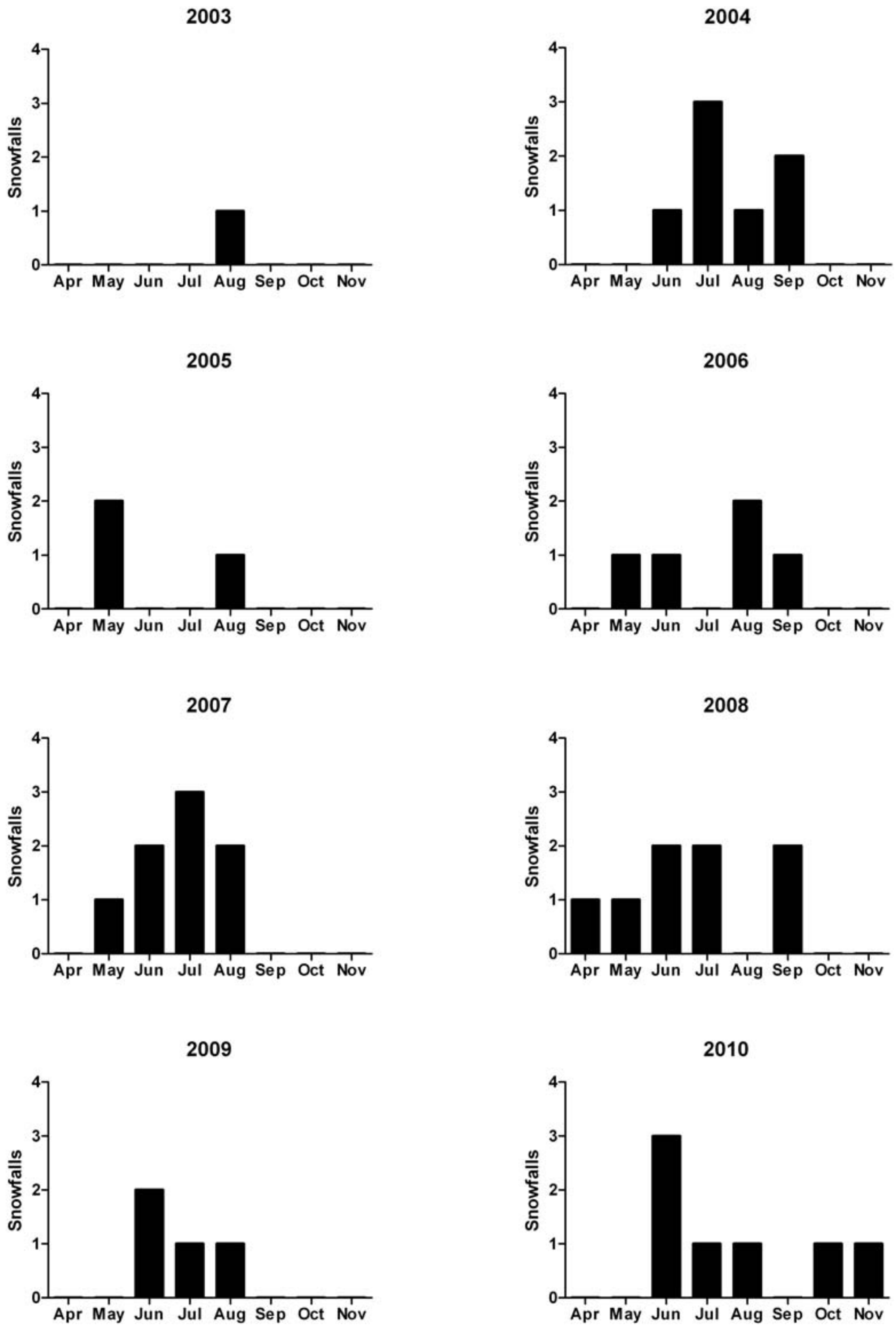

Figure 5.13: MODIS monthly snowfall frequency for the period 2003 – 2010.

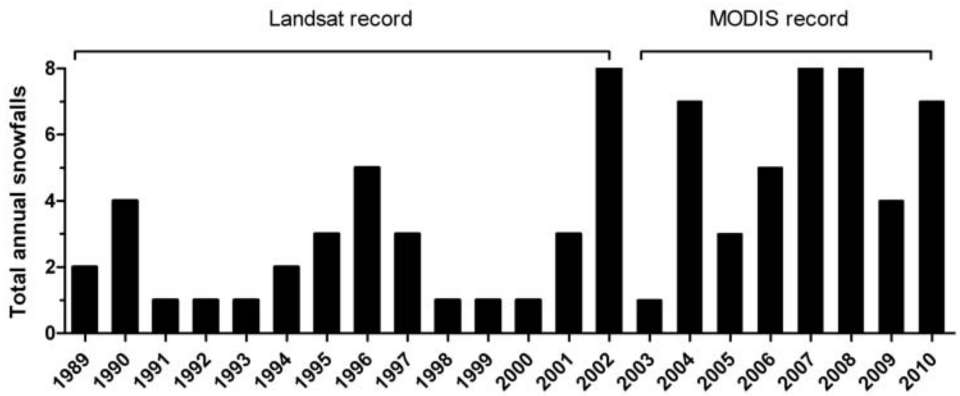

Figure 5.14: Total annual snowfalls for the period 1989 – 2010 based on Landsat and MODIS images.

Based on Landsat snow cover imagery for 14 years for the period 1989 – 2002, a total of 37 snowfalls were recorded, with a mean of 2.64 snowfalls per annum (Table 5.4). The absolute maximum number of snowfalls per annum was highest during the early season period (4), followed by the mid season (3) and late season (2) periods (Figure 5.15). However, the mid season period represents the highest mean maximum number of snowfalls per annum (1.21), as well as the highest mean minimum number of snowfalls per annum (0.36) (Figure 5.15). The month with the highest snowfall frequency is July (1.2 snowfalls per annum), although most snowfalls occurred in August (11) (Table 5.5). Consequently, the highest number of snowfalls (17) occurs during the mid season period (July – August). A total of 12 early season (April – June) and 8 late season snowfalls (September – November) were recorded.

Based on MODIS snow cover imagery for 8 years from the period 2003 – 2010, most snowfalls (19) occurred during the mid season months of July and August (Table 5.6). However, the month with the highest snowfall frequency is June (1.38 snowfalls per annum). A total of 17 early season (April – June) and 7 late season snowfalls (September – November) were recorded. The mid season period has the highest absolute maximum number of snowfalls per annum (5), as well as the highest mean maximum number of snowfalls per annum (2.38) (Figure 5.16). Late season snowfalls have the lowest absolute maximum number of snowfalls per annum (2), and the lowest mean maximum number of snowfalls per annum (0.88).

Table 5.4: Statistical comparison of annual snowfall frequency derived from MODIS and Landsat records.

	MODIS	Landsat
Mean	5.38 per annum	2.64 per annum
Median	6 per annum	2.5 per annum
Standard Deviation	2.56 per annum	2.02 per annum
Minimum	1 per annum	1 per annum
Maximum	8 per annum	8 per annum
Snowfalls	43	37

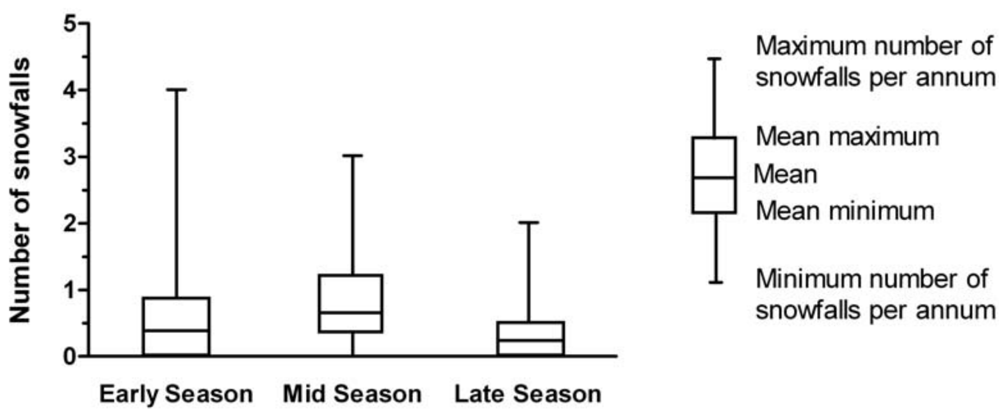

Figure 5.15: Total and mean number of seasonal snowfall events for the period 1989 – 2002 based on Landsat imagery.

Table 5.5: Statistical summary of monthly snowfall frequency per annum for the period 1989 – 2002 based on Landsat records.

	April	May	June	July	August	September	October	November
Mean per annum	0.07	0.36	0.43	1.2	0.79	0.36	0.21	0
Median	0	0	0	0	1	0	0	0
Standard Deviation	0.27	0.63	0.65	0.45	0.58	0.50	0.43	0
Minimum	0	0	0	0	0	0	0	0
Maximum	1	2	2	2	2	1	1	0
Sum	1	5	6	6	11	5	3	0

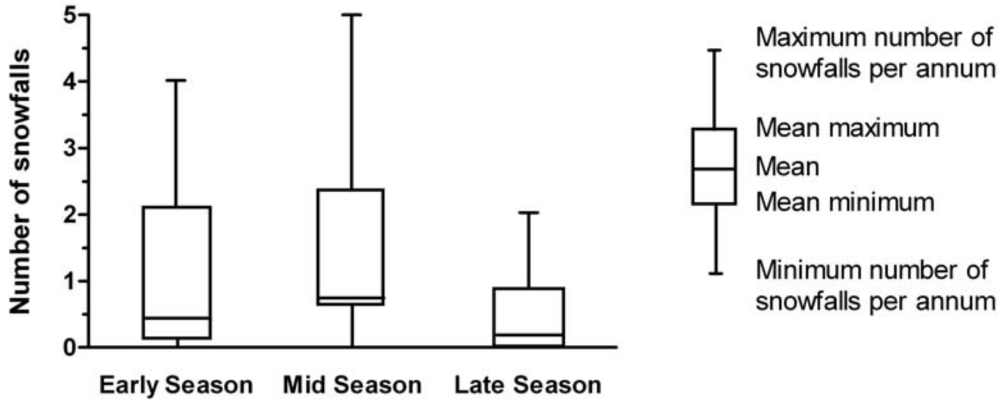

Figure 5.16: Total and mean number of seasonal snowfall events for the period 2003 – 2010 based on MODIS imagery.

Table 5.6: Statistical summary of monthly snowfall frequency per annum for the period 2003 – 2010 based on MODIS imagery.

	April	May	June	July	August	September	October	November
Mean per annum	0.13	0.63	1.38	1.25	1.13	0.63	0.13	0.13
Median	0	0.50	1.50	1	1	0	0	0
Standard Deviation	0.35	0.74	1.06	1.28	0.64	0.92	0.35	0.35
Minimum	0	0	0	0	0	0	0	0
Maximum	1	2	3	3	2	2	1	1
Snowfalls	1	5	11	10	9	5	1	1

5.3.2 Snow cover extent

Snowfall extent derived from MODIS images indicates that 2004 had the highest cumulative extent of snowfall (25788.95 km^2) from 7 snowfalls, whilst 2005 had the lowest cumulative snowfall extent (1065.78 km^2) from 3 snowfalls (Table 5.7). Given the high interannual variability in the frequency of snowfalls, the extent of snowfalls exhibits similar interannual and interseasonal variability (Figure 5.17). The highest mean snowfall extent (5414.11 km^2) within a given year was recorded in 2003, owing to the fact that only one generally widespread snowfall was recorded during that year. However, the lowest mean snowfall extent within a given year (355.26 km^2) was recorded in 2005, when three snowfalls were captured. The single largest snowfall was recorded in August 2006 with an extent of 15564.20 km^2, whilst the smallest snowfall extent (82.91 km^2) was recorded in June 2004 (Table 5.7).

Table 5.7: Statistical summary of snowfall extent for the period 2003 - 2010, based on MODIS imagery.

	Snowfalls	**Cumulative snowfall extent (km^2)**	**Mean snowfall extent (km^2)**	**Minimum (km^2)**	**Maximum (km^2)**	**Standard Deviation**
2003	1	5414.11	5414.11	-	-	-
2004	7	25788.95	3684.14	82.91	9828.24	4084.90
2005	3	1065.78	355.26	255.06	500.44	128.72
2006	5	21896.73	4379.35	161.39	15564.20	6650.46
2007	8	19301.02	2412.63	158.18	5633.11	2201.82
2008	8	27001.67	3375.21	631.71	7454.98	2910.28
2009	4	16528.38	4132.10	756.57	9746.14	4283.82
2010	7	4250.00	607.14	175.00	1970.00	611.78

The mean duration of SCA following a snowfall is highest during July (11 days), followed closely by June (9.8 days) and August (9.7 days) (Figure 5.18). The duration of snow cover following snowfalls is progressively lower during the months of May (7.4 days), September (5.2 days), April (2 days) and October (1 day) and November (1 day) (Table 5.8). The mean seasonal duration of snow cover increases considerably from May, indicating that the onset of the early winter season quickly leads to prolonged snow cover (Figure 5.18). The seasonal duration of snow cover is highest after mid season snowfalls, peaking in the month of July. However, with the onset of the late season months, snow cover duration decreases rapidly after August. This trend is due to accelerating snowmelt rates associated with warmer spring conditions in September, and is lower during the early season period, suggesting better snow preservation during autumn (April/May) than spring (September/October).

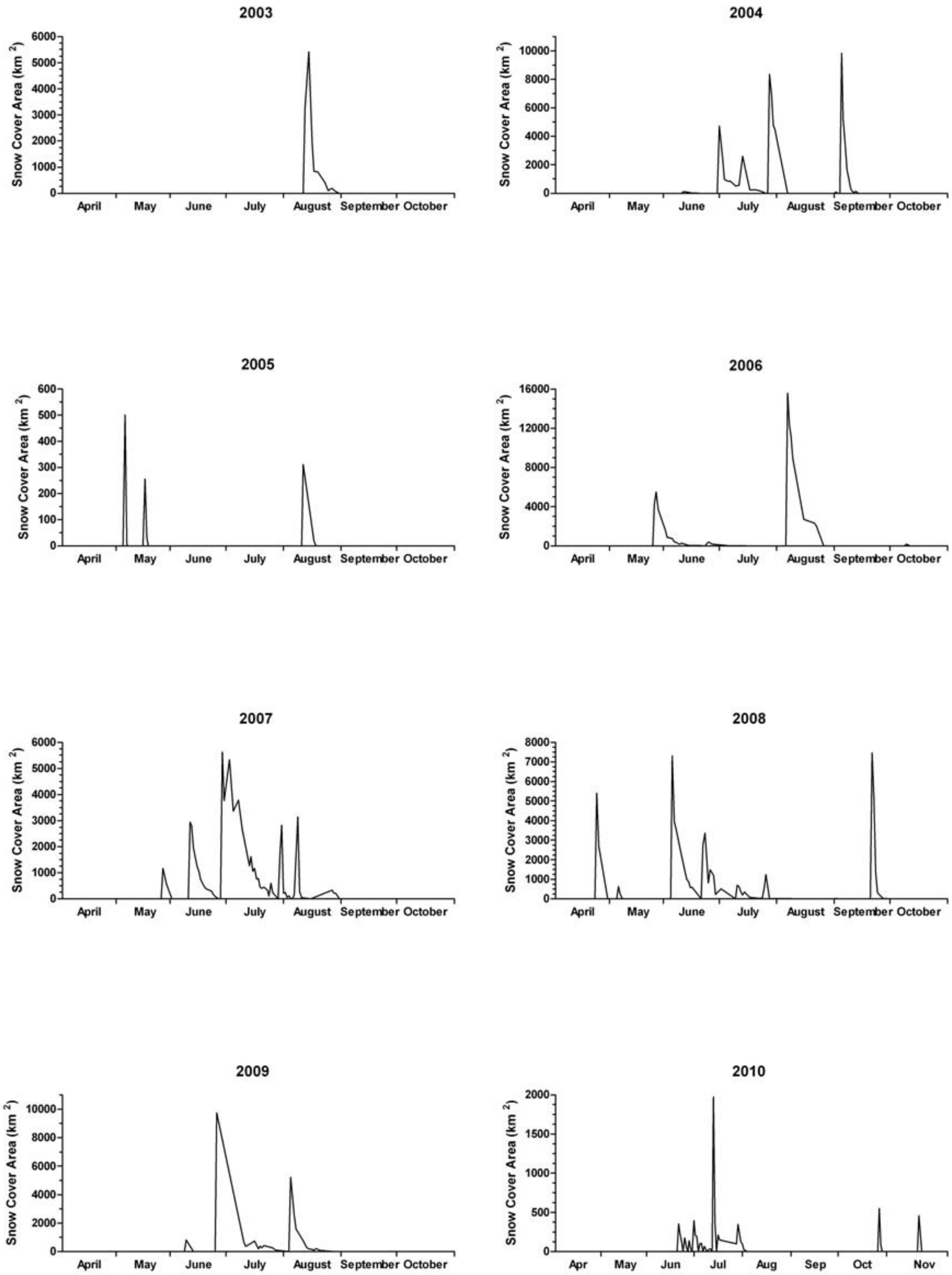

Figure 5.17: Annual snowfall extent for the period 2003 – 2010 based on MODIS satellite images.

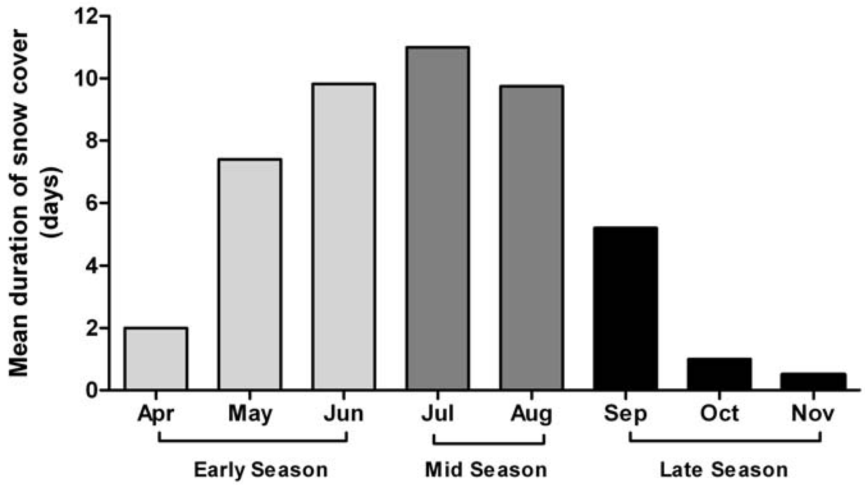

Figure 5.18: Mean duration of seasonal snow cover for the period 2003 – 2010.

Table 5.8: Statistical summary of monthly snow duration (days) for the period 2003 - 2010.

	April	May	June	July	August	September	October	November
Mean	2	7.4	9.8	11	9.7	5.2	1	1
Median	-	3	7	11	7	4	1.5	-
Standard Deviation	-	10.85	6.06	5.73	7.97	4.09	0.71	-
Minimum	-	2	1	2	2	1	1	-
Maximum	-	27	20	23	25	10	2	-
Count	1	5	11	10	8	5	2	1

5.3.3 Snow dissipation and temperature

The relationship between snow-covered area, mean daily melt and mean day-time and nocturnal temperature is explored for all MODIS snowfall events for which temperature data were available. Mean day-time and nocturnal temperatures were calculated based on daily measurements recorded by a weather station near Sani Pass on the Drakensberg escarpment, therefore the mean day-time and nocturnal temperatures provide an indication of broad, regional termperature trends. Any relationship between mean temperatures and the melt rate is thus a relative comparison. Snow cover area is expressed as the percentage of remaining snow cover from the original snowfall event, whilst the mean daily melt rate is expressed as the percentage decrease of remaining snow cover from the previous day. Temperature data were available for a total of 16 snowfall events. The first snowfall is an early season event occurring in 2004, with snow lasting 10 days. During the first three days after the snowfall on 11 June 2004, mean day-time temperatures increased from 1.4ºC to 3.6ºC, a trend that coincides with a decrease in SCA to 53.2% as a result of a higher mean daily melt rate of 21.1%/day (Figure 5.19). Five days after the initial snowfall, SCA decreased to 14.6% whilst the rate of mean daily melt increased to 60.6%/day. Six days after the snowfall, the SCA (11%) is decreasing less rapidly, whilst the mean daily melt rate decreased to 8%/day. Between seven and ten days after the snowfall, mean day-time temperatures rise to 6.7ºC whilst mean nocturnal temperatures remain below 0ºC. During this period, SCA decreases at a slower rate from 7% until complete disappearance 10 days after the snowfall. The rate of snowmelt during this time increases rapidly to 51.1%/day. Increased day-time and nocturnal temperatures appear to be associated with accelerated rates of snowmelt eight days after the initial snowfall (Figure 5.19).

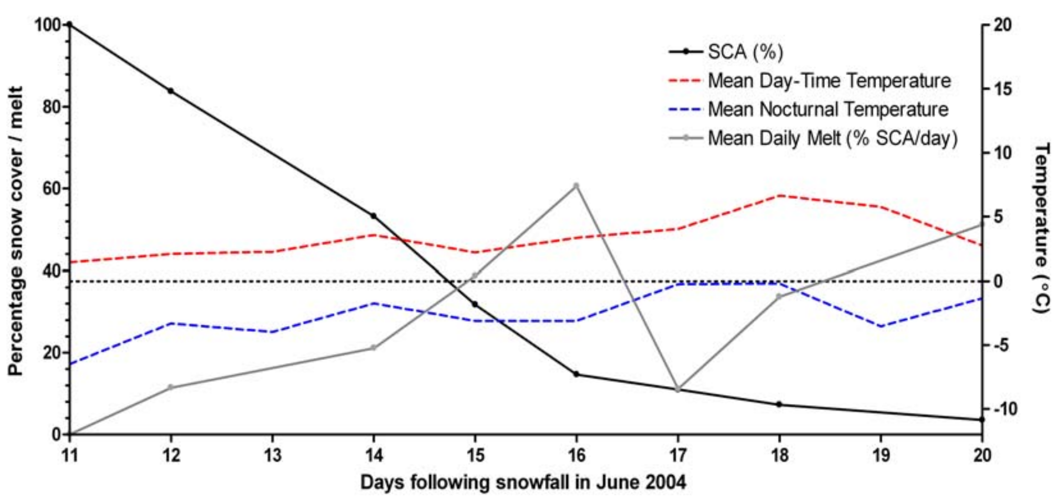

Figure 5.19: Relationship between SCA, snowmelt and temperature for the period 11 - 20 June 2004.

A mid season snowfall event was recorded on 1 July 2004, with snow lasting for 11 days (Figure 5.20). Two days after this snowfall, SCA decreased to 51.6% with a daily melt rate of 24.2%/day whilst mean day-time temperatures (5ºC) and nocturnal temperatures (1.8ºC) were the highest throughout the 11-day period. Between three and five days after the snowfall, day-time and nocturnal temperatures had decreased to –3.7ºC and –5.6ºC respectively. During this period of cooler conditions, remaining SCA decreased from 20.4% to 10.4% of the original snow cover, or by less than 11%/day. Nine days after the snowfall day-time temperatures average close to 0ºC, when snowmelt accelerates to 23.5%/day (Figure 5.20).

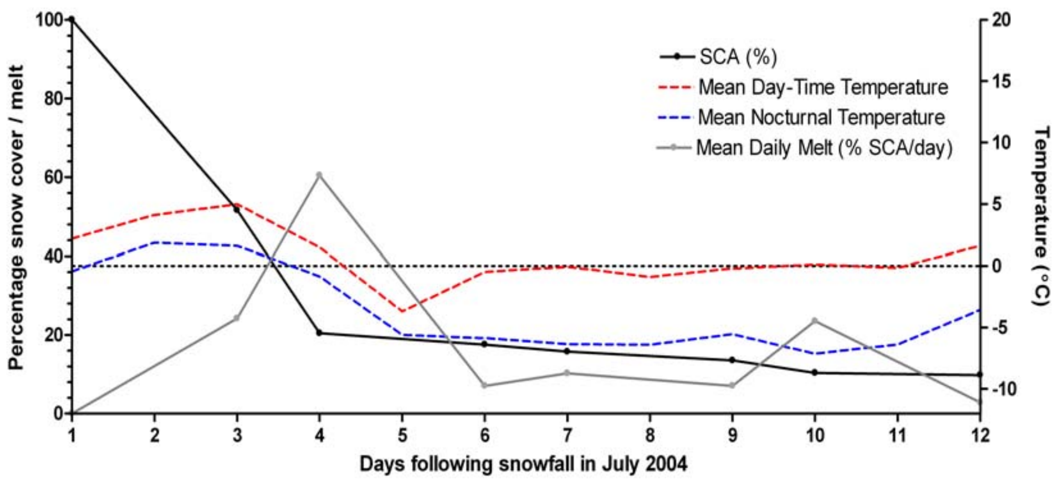

Figure 5.20: Relationship between SCA, snowmelt and temperature for the period 1 - 12 July 2004.

Snow cover from a snowfall occurring on 14 July 2004 lasted 13 days, and was associated with a low mean day-time temperature (-4.5ºC) and mean nocturnal temperature (-7.5ºC) on that day (Figure 5.21). Four days after this snowfall, mean day-time temperature had increased to 1ºC whilst nocturnal temperature had increased to –5.7ºC. During this period, SCA had decreased to 9.5%, with the mean daily melt rate increasing to 22.6%/day. Five days after the snowfall, the rate of daily melt was substantially reduced to 9.4%/day as SCA decreased marginally to 8.6%. This decrease in the rate of snowmelt coincided with a low mean day-time temperature (1.5ºC) and nocturnal temperature (–4.5ºC). Between eight and nine days after the snowfall, the mean daily and nocturnal temperatures increased to 6.9ºC and

1ºC respectively. This period of warming lasted until 12 days after the snowfall when daily and nocturnal temperatures decreased to –3.1ºC and –2.8ºC respectively. However, the brief warming phase between eight to nine days after the snowfall was followed by an accelerated rate of mean daily snowmelt (41%/day) 11 days after the snowfall event, with 3.5% of the original SCA remaining (Figure 5.21).

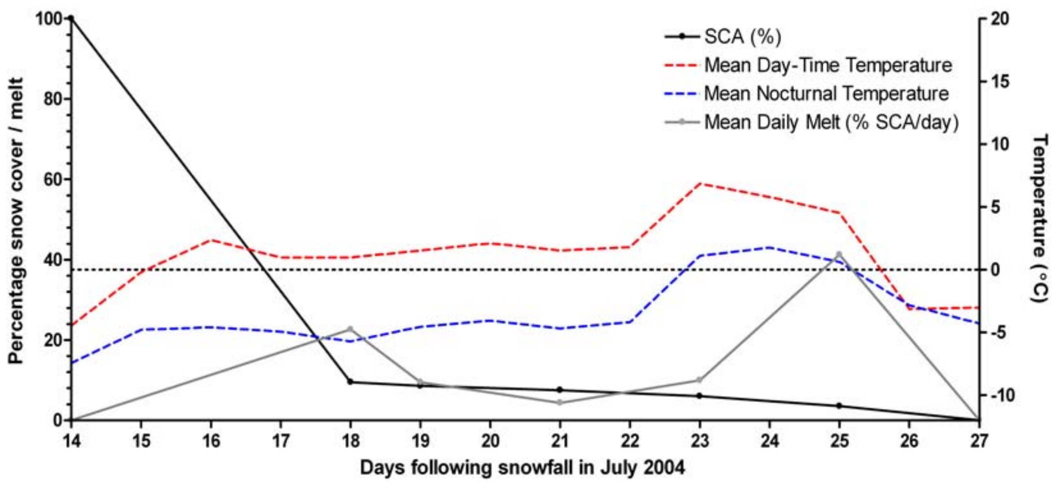

Figure 5.21: Relationship between SCA, snowmelt and temperature for the period 14 - 25 July 2004.

A mid season snowfall event occurred on 29 July 2004, and lasted a total of 10 days (Figure 5.22). This event was associated with low mean day-time and nocturnal temperatures of –4.6ºC and –7.6ºC respectively. However, one day after the snowfall daily and nocturnal temperatures had increased marginally to –0.8ºC and –3.4ºC respectively, which coincides with a mean daily snowmelt of 17%/day. Three days after the snowfall mean daily and nocturnal temperatures decreased to –2.3ºC and –8ºC, yet the daily melt rate increases to 31.2%/day during this period. Between three and ten days after the snowfall, mean daily and nocturnal temperatures increase steadily to 9.9ºC and 7.2ºC respectively. Ten days after the snowfall, the mean rate of melt is 14.3%/day which has led to the complete dissipation of the snow covered area (Figure 5.22).

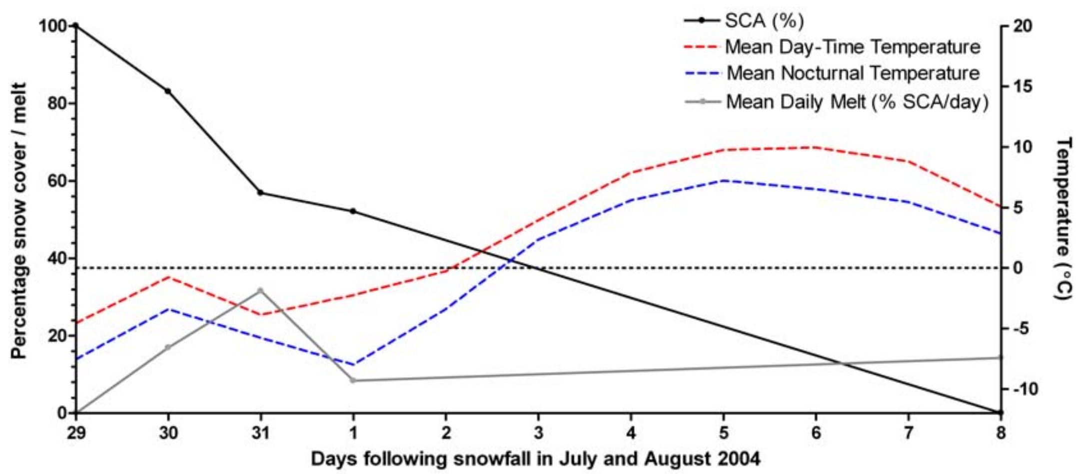

Figure 5.22: Relationship between SCA, snowmelt and temperature for the period 29 July - 8 August 2004.

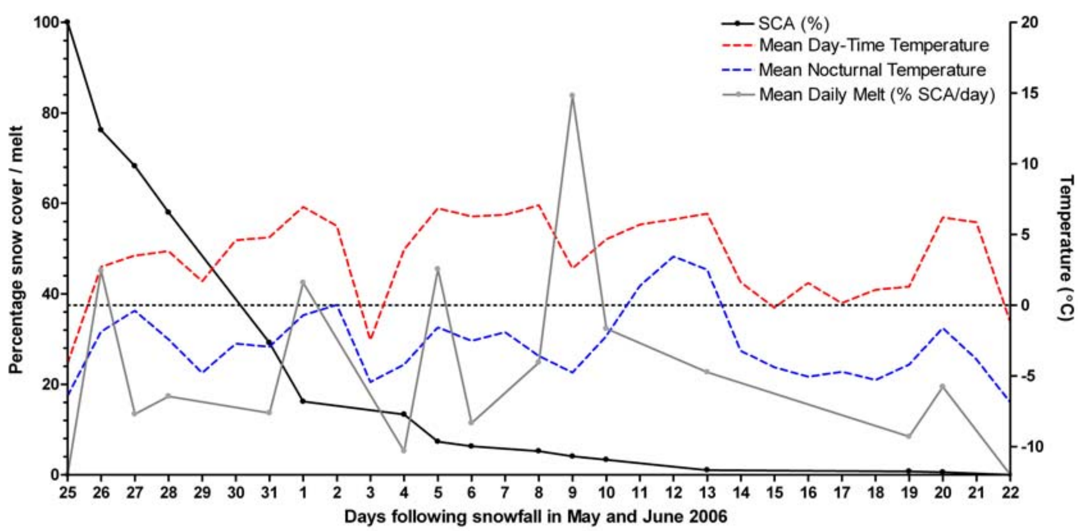

Figure 5.23: Relationship between SCA, snowmelt and temperature for the period 25 May - 20 June 2006.

An early season snowfall occurred on 25 May 2006, producing snow cover that lasted for 28 days (Figure 5.23). The onset of this event was associated with low mean day-time and nocturnal temperatures of –4.1ºC and –6.4ºC respectively. One day after the snowfall, these temperatures increased to 2.7ºC and –1.9ºC, coinciding with a daily melt rate of 45%/day. During this period, SCA decreased to 76.2%. However, two days after the snowfall, the rate of daily melt had decreased considerably to 13.4%/day, and as a result SCA decreased only marginally to 68.2% of the original snow extent. Between two and six days after the snowfall, mean daily and nocturnal temperatures decreased to 1.7ºC and –4.8ºC respectively. This cooling trend coincided with a gradual decrease in the rate of mean daily melt to 13.7%/day, and SCA had decreased to 29.2% of the original snow extent. An accelerated rate of daily melt occurred seven days after the snowfall, coinciding with daily and nocturnal temperature increases to 6.9ºC and –0.7ºC respectively. However, by nine days after the snowfall, daily and nocturnal temperatures decreased considerably to –2.5ºC and –5.4ºC, coinciding with a lower rate of SCA depletion from 16.2% seven days after to 13.3% ten days after the snowfall. The mean daily melt exhibited a similar trend, decreasing from 42.5%/day seven days after to 5.2%/day ten days after the snowfall. Rising daily and nocturnal temperatures eleven days after the snowfall coincided with an elevated rate of mean daily melt (45.5%/day) whilst SCA decreased to 7.4%. Twelve days after the snowfall, the rate of daily melt decreased to 11.5%/day, whilst mean daily and nocturnal temperatures remained stable (6.9ºC and –1.6ºC respectively). A subsequent decrease in daily and nocturnal temperatures to 2.6ºC and –4.8ºC, fifteen days after the snowfall, coincided with an increased rate of daily snowmelt (83.8%/day). However, the gradual decrease in SCA continued until nineteen days after the snowfall, when decreasing day-time temperatures (1.6ºC) and nocturnal temperatures (–3.2ºC) coincided with a slow low rate of mean daily melt (22.7%/day). Daily and nocturnal temperatures remained below 6.5ºC and –1ºC respectively until SCA was entirely depleted, 28 days after the initial snowfall event (Figure 5.23).

A mid season snowfall was recorded on 4 August 2009, with SCA lasting for a total of 24 days (Figure 5.25). The onset of this snowfall was associated with average daily and nocturnal temperatures of 1.5ºC and –2ºC respectively. Two days after the snowfall, SCA had decreased to 50%, at a rate of 25%/day. SCA decreased at a slightly elevated rate of 40%/day to 30% three days after the snowfall. Seven days after the snowfall, SCA had decreased to 13%, representing a mean daily melt rate of 14%/day. The mean daily and nocturnal temperatures increased to 7.4ºC and 0.6ºC respectively.

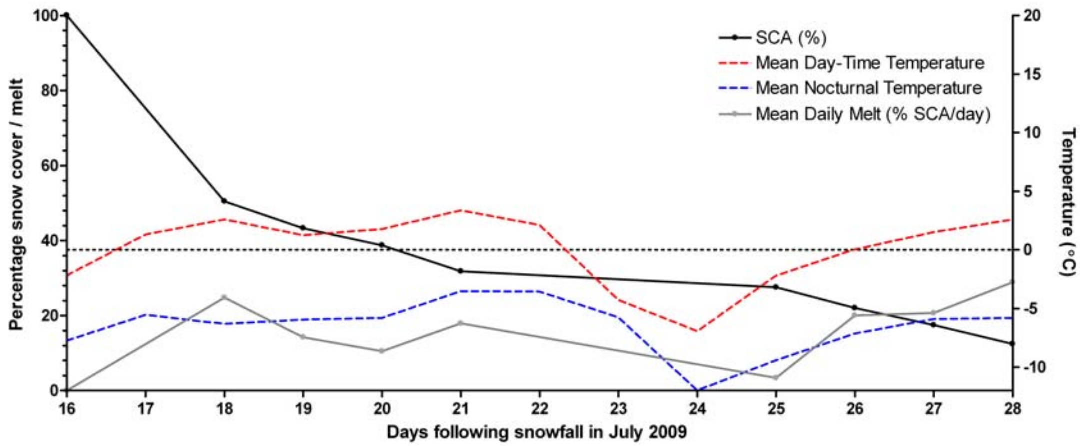

Figure 5.24: Relationship between SCA, snowmelt and temperature for the period 16 July – 28 July 2009.

Twenty days after the snowfall, the average daily and nocturnal temperatures decreased to 1.5ºC and –3.6ºC respectively, coinciding with a decreased daily snowmelt rate of 39%, with SCA of 4%. Between 17 and 24 days after the snowfall, SCA had decreased gradually from 1.2% to 0.08%, as the average daily and nocturnal temperatures decreased to –2.7ºC and –5.2ºC respectively during this period. Daily and nocturnal temperatures increase 21 days after the snowfall coinciding with relatively low rates of mean daily melt (19.3%/day).

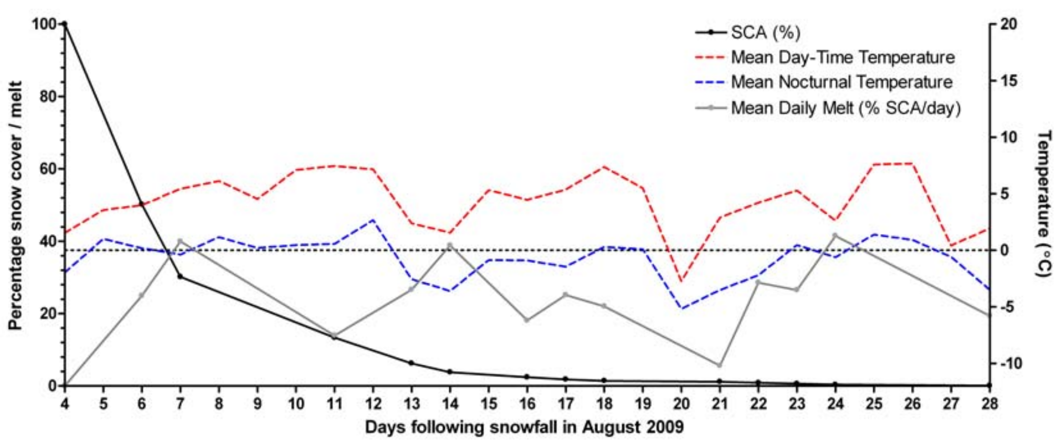

Figure 5.25: Relationship between SCA, snowmelt and temperature for the period 4 - 28 August 2009.

Table 5.9: Statistical relationships between mean day-time and nocturnal temperatures and mean daily snowmelt rates derived from MODIS imagery for the period 2003 - 2010.

		11-Jun-04	01-Jul-04	14-Jul-04	29-Jul-04	25-May-06	24-Jun-06	04-Aug-06	28-Sep-06	26-Jun-09	16-Jul-09	04-Aug-09	19-Jun-10	23-Jun-10	28-Jun-10	14-Jul-10	20-Aug-10
	Mean melt rate (% snow cover / day)	25.32	16.91	12.52	14.23	24.11	22.71	12.30	55.57	23.15	15.59	23.64	20.06	36.75	27.10	31.53	63.25
	Median	21.12	8.64	9.47	14.28	18.39	17.68	11.61	62.90	22.98	17.89	25.04	23.70	48.10	21.23	26.43	76.50
	Standard Deviation	21.95	19.69	14.85	11.67	21.73	21.57	8.83	45.70	23.24	9.57	12.06	14.22	22.02	32.75	30.87	44.64
	Minimum melt rate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Maximum melt rate	60.59	60.41	41.22	31.55	83.79	59.12	20.98	96.49	46.63	28.92	41.48	32.83	51.74	81.28	73.27	100
Correlation with mean day-time temperatures	**r^2 value**	0.11	0.04	0.32	0.00	0.11	0.15	0.26	0.88	0.22	0.64	0.00	0.02	0.25	0.18	0.05	0.63
	***P* value**	0.37	0.64	0.19	0.93	0.22	0.45	0.38	0.06	0.53	**0.01**	0.92	0.85	0.39	0.47	0.78	0.20
Correlation with mean nocturnal temperatures	**r^2 value**	0.13	0.10	0.30	0.05	0.05	0.09	0.24	0.62	0.21	0.31	0.02	0.04	0.45	0.16	0.00	0.41
	***P* value**	0.35	0.45	0.20	0.73	0.42	0.57	0.40	0.21	0.54	0.12	0.64	0.80	0.22	0.50	0.96	0.36

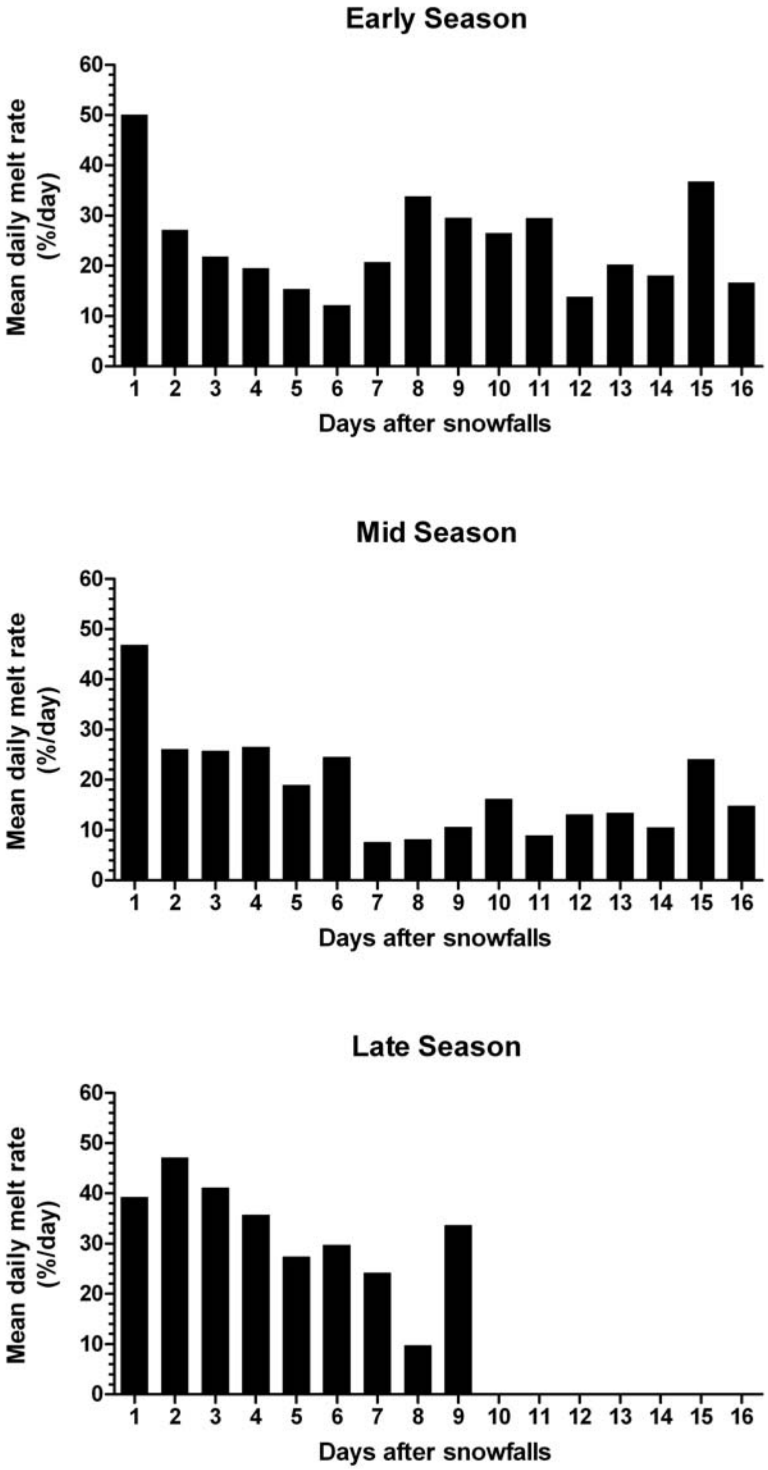

Figure 5.26: Seasonal summaries of mean snowmelt rates for successive days after snowfalls occurring during the period 2003 – 2010.

5.3.3.1 Statistical relationships between temperatures and snowmelt

The mean daily melt rate and mean day-time temperatures are compared statistically 1 – 5 days and 6 – 10 days after snowfalls for early, mid and late season snowfalls. Snowmelt rates are derived from the MODIS database for the period 2003 – 2010, and mean day-time temperatures are from the Sani Top weather station. The correlation between daily snowmelt rates and average day-time temperatures for early season snowfalls yields coefficients of r^2 = 0.0065 for 1 – 5 days after snowfalls (n = 19) and r^2 = 0.1052 (n = 12) for 6 – 10 days after snowfalls (Figure 5.27). Although the early season correlation coefficients indicate weak positive relationships between the rates of snowmelt and average day-time temperatures, the relationships are not statistically significant. The 1 – 5 day correlation has a P value of 0.7423, whilst the corresponding 6 – 10 day P value is 0.3038. For the 6 – 10 day interval, increasing mean day-time temperatures are associated with a 9.74% increase in the dissipation of snow cover per ºC rise in temperature, compared to an 8% increase in the dissipation of snow cover per ºC rise in temperature represented by the1 – 5 day interval (Figure 5.27).

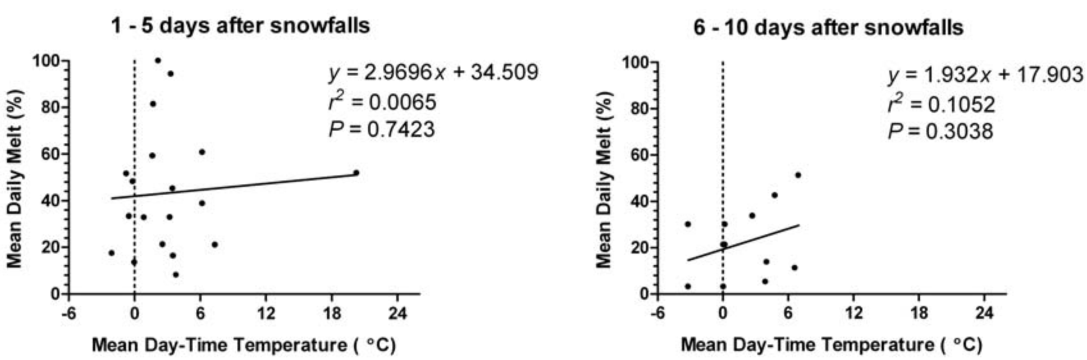

Figure 5.27: Correlation between mean daily snowmelt and day-time temperature for early season snowfalls.

The correlations between mean rate of daily snowmelt and mean day-time temperatures for mid season snowfalls yield coefficients of r^2 = 0.2762 for 1 – 5 days after the snowfalls (n = 26), and r^2 = 0.5008 for 6 – 10 days following snowfall (n = 8) (Figure 5.28). Both correlations indicate the presence of positive relationships between the mean rate of daily snowmelt and mean day-time temperatures after mid season snowfalls, and the relationships are statistically significant. For the mid season period, the 1 – 5 day correlation has a *P* value of 0.0058, whilst the corresponding 6 – 10 day *P* value is 0.0496. For the 1 – 5 day interval, there is a –1.5% decrease in the dissipation of snow cover per ºC rise in temperature, compared to a 1% increase in the dissipation of snow cover per ºC rise in temperature represented by the 6 – 10 day interval (Figure 5.28).

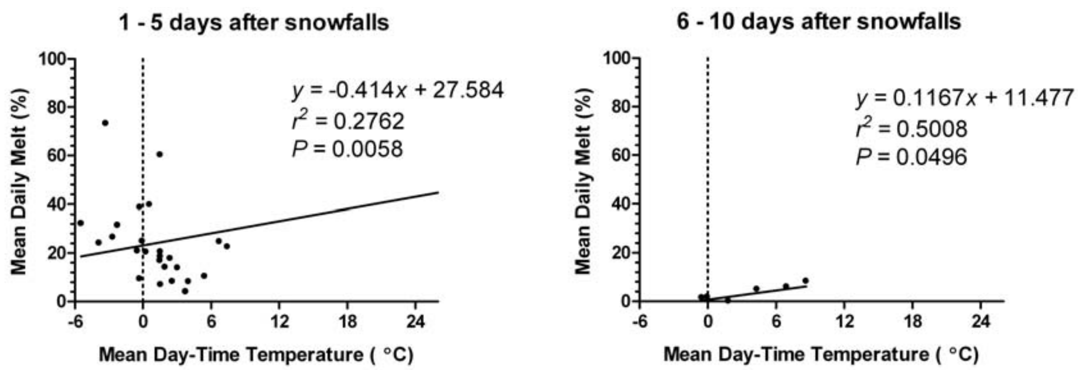

Figure 5.28: Correlation between mean daily snowmelt and day-time temperature for mid season snowfalls.

The correlations between mean rate of daily snowmelt and average day-time temperatures of late season snowfalls have coefficients of r^2 = 0.1198 for 1 – 5 days after snowfalls (n = 9), and r^2 = 0.07639 for 6 – 10 days following snowfalls (n = 4) (Figure 5.29). For late season snowfalls, the 1 – 5 day correlation has a *P* value of 0.3615, whilst the corresponding 6 – 10 day *P* value is 0.7236, thus indicating that the relationships between mean rates of daily snowmelt and mean day-time temperatures are not statistically significant. For the late season 1 – 5 day interval, there is a 0.2% increase in the dissipation of snow cover per ºC rise in temperature, whilst a 5.7% increase in the dissipation of snow cover per ºC rise in temperature is represented by the 6 – 10 day interval (Figure 5.29). However, a limiting factor with the late season snowfalls is the small sample sizes available. Therefore, statistical comparisons are not necessarily accurate reflections of the true relationships between late season snowmelt rates and day-time temperatures.

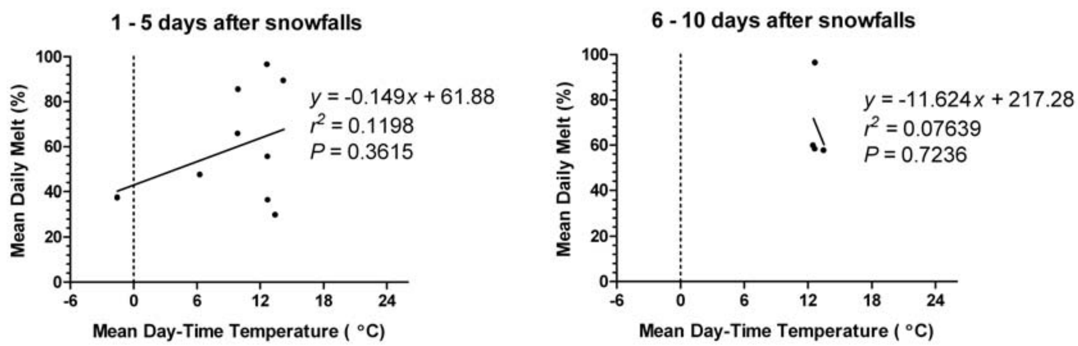

Figure 5.29: Correlation between mean daily snowmelt and day-time temperature for late season snowfalls.

Despite small sample sizes for late season snowfalls, the correlation of mean daily snowmelt and temperature from all early, mid and late season snowfall events yields robust statistical results (Figure 5.30). The correlations between mean rate of daily snowmelt and average day-time temperatures of snowfalls have coefficients of r^2 = 0.1475 for 1 – 5 days after snowfalls (n = 54), and r^2 = 0.4276 for 6 – 10 days following snowfalls (n = 24). The 1 – 5 day correlation has a P value of 0.0041, whilst the corresponding 6 – 10 day P value is 0.0005, thus indicating that the relationships between mean rates of daily snowmelt and mean day-time temperatures are indeed statistically significant. For the 1 – 5 day interval, there is a 1.2% increase in the dissipation of snow cover per ºC rise in temperature, compared with an 8.5% increase in the dissipation of snow cover per ºC rise in temperature represented by the 6 – 10 day interval (Figure 5.30).

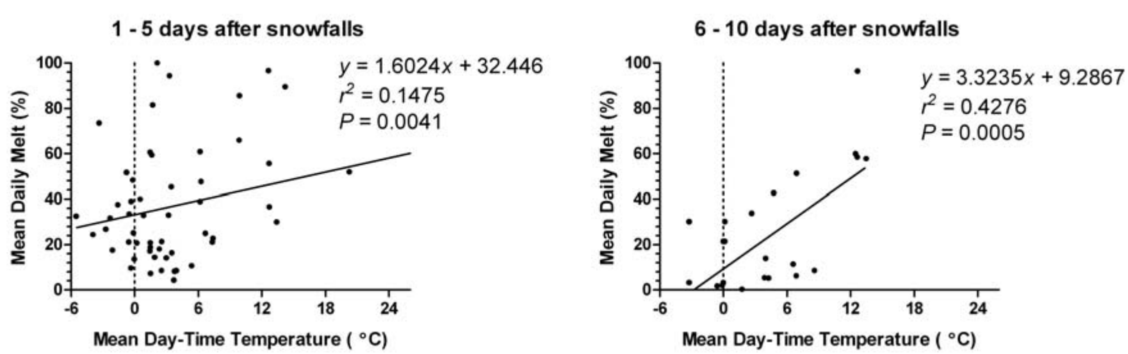

Figure 5.30: Correlation between mean daily snowmelt and day-time temperature for all snowfalls.

5.3.4 Extended overview of seasonal snowmelt rates

Interseasonal relationships between the rates of mean daily melt and topographic elements (altitude and slope gradient) are investigated for 1 – 5 days and 6 – 10 days following snowfalls in Lesotho. As snow cover often persists for only a few days, and seldom lasts longer than 10 days, snowmelt dynamics can be best represented by two intervals each summarizing 5 days of snow cover. Mean rates of melt were calculated from snow cover area measurements based on MODIS SNOMAP imagery. The number of recorded instances of snow cover used to derive the mean rates of snowmelt appears in the legend of each graph. The rate of snowmelt is expressed as the percentage loss of snow cover on a daily basis, from both the original snowfall and the extent of snow cover remaining from the previous day.

For snowfalls occurring during the early season, original snow cover melts most rapidly at an altitude of 1350m a.s.l, where it disappears within a day (Figure 5.31). Little snow cover remains for longer than 5 days below 1500m a.s.l due to the high rate of melt. Remaining snow cover melts quickly at 1760m a.s.l, with 56% of the snow cover area melting each day. However, snowmelt above 3100m a.s.l occurs at a slower rate (30%/day). Although the spatial extent of snow cover at high altitudes is proportionally less than the extent of the original snowfall, snow cover persists for longer than at lower altitudes for early season snowfalls. For mid season snowfalls, melting of the original snow cover occurs rapidly at low altitudes, reaching a maximum rate of 80%/day at 1500m a.s.l (Figure 5.31).

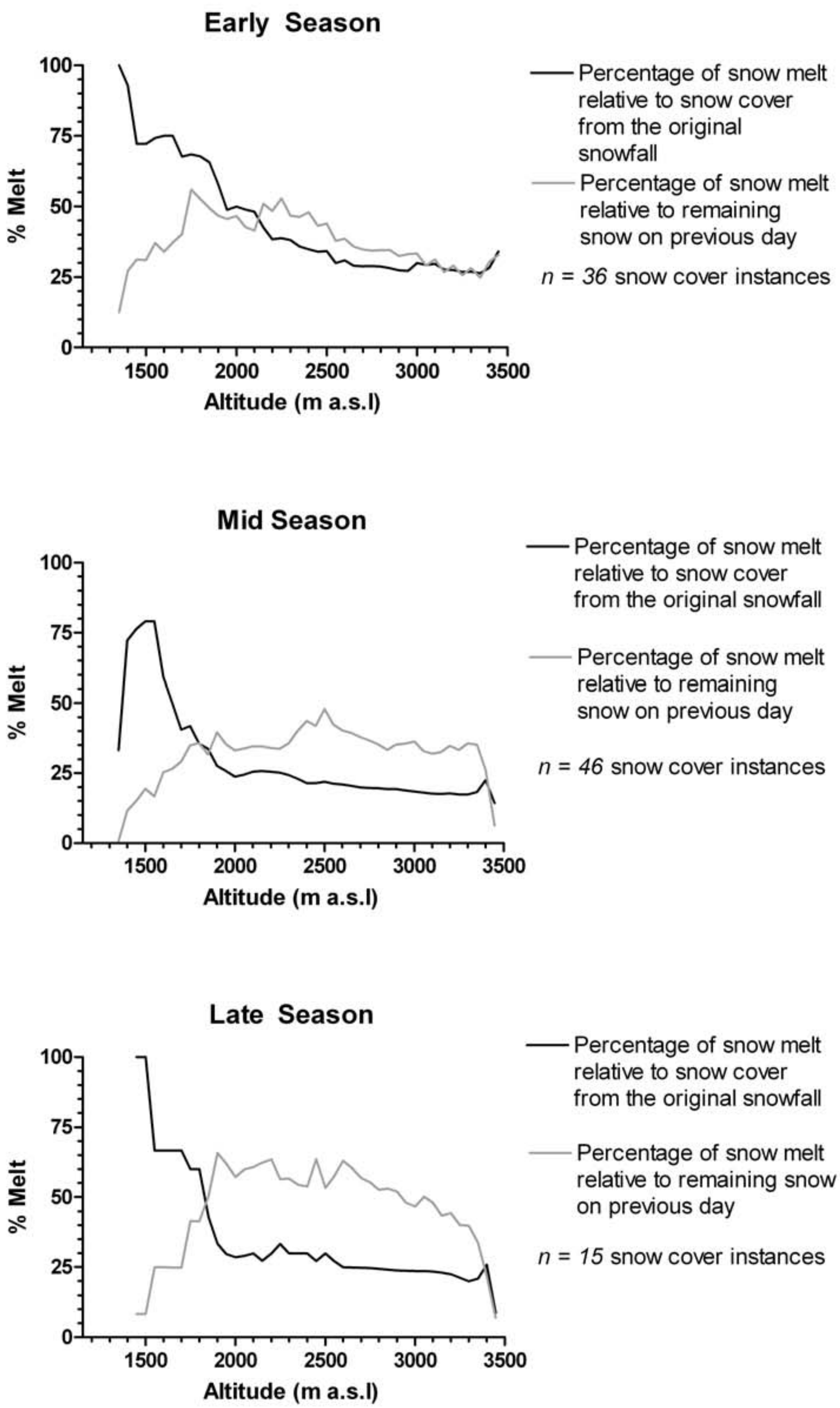

Figure 5.31: Seasonal relationships between mean daily snowmelt and altitude 1 – 5 days after snowfalls.

The rate of melt is lower during the mid season than for early season snowfalls, which indicates that mid season snow cover persists for longer than during the early season period (Figure 5.31). Further, original snow cover melts at a slower rate (<25%/day) above 2000m a.s.l than during the early season period. However, for remaining snow cover during the mid season period, snow is depleted most rapidly at 2500m a.s.l, with 47% of the snow cover melting each day. The maximum rate of melt of remaining mid season snow cover (47%/day) occurs at 2500m a.s.l, the maximum early season melt rate (54%/day) occurs at a lower altitude (1750m a.s.l). Snow cover above 3100m a.s.l melts by 30%/day on average following early and mid season snowfalls, however late season snow cover dissipates more rapidly (40%/day on average) above 3100m a.s.l. The maximum rate of melt of remaining snow cover during the mid season period is 11% slower than for the early season period. Therefore, snow cover persists for longer during the mid season period, as less snow melts on a day-to-day basis. The rates of snowmelt during the late season period are similar to those of early season snowfall events, where most snow cover melts within 1 – 5 days after the snowfalls (Figure 5.31). However, snow cover from original snowfalls dissipates by an average of 100% each day at 1450m a.s.l. This altitude is 100m higher than the early season altitude of maximum melt (1350m a.s.l), indicating that snow cover generally persists for a shorter period during late season snowfalls, and begins to melt faster at higher altitudes than during the early season. Remaining snow cover from the previous day melts quickest at an altitude of 1900m a.s.l, dissipating at a rate of 67%/day yet remaining near 60%/day up to 2700m a.s.l (Figure 5.31). Snow cover remaining from the original snowfall above 3100m a.s.l melts most rapidly after early season snowfalls by 30%/day on average. Original snow cover melts less rapidly above 3100m a.s.l following late season snowfalls (25%/day on average) and least rapidly after mid season snowfalls (20%/day on average). The rate of melt is more rapid and the altitude at which it occurs is higher during the late season period than for the early season period. This indicates that late season snowfall melts more rapidly than both the early and mid season periods, and with accelerated melting at higher altitudes than early and mid season snowfalls.

Snow cover in Lesotho may last for only a few days before dissipating completely. Therefore, there are fewer occurrences of snow cover lasting for up to 10 days (32% of occurences) than of snow cover lasting for less than 5 days (64% of occurrences). For early season snowfalls where snow cover persisted for between 6 and 10 days, snow cover from the original snowfall melts at a maximum rate of 15%/day at an altitude of 3400m a.s.l (Figure 5.32). This rate is 85%/day slower than for snow cover lasting for between 1 and 5 days during the early season period. With another peak value of 13%/day at 1900m a.s.l, snowmelt occurs less rapidly at altitides from 2050m a.s.l – 3000m a.s.l. An analysis of the early season melt rate of remaining snow cover from previous days reveals dissipation of around 40% of the snow cover area each day between 2100m a.s.l – 3350m a.s.l, with the most rapid rate of melt (45%/day) occurring at 2950m a.s.l and the least rapid rate (15%/day) occurring at 1950m a.s.l (Figure 5.32). This indicates that snow cover persists longer at high altitudes than at lower altitudes between 6 and 10 days after snowfalls during the early season period. For mid season snowfalls, snow cover melts far slower than during the early season. Original snow cover dissipates at a rate of 5%/day on average, whilst the melt rate of snow cover remaining from the previous day remains below 24%/day at all altitudes (Figure 5.32). This indicates that snow cover dissipates by between 10%/day and 25%/day for altitudes between 1900m a.s.l – 3400m a.s.l during the mid season. Few instances of late season snow cover persisting for between 6 and 10 days were recorded (n = 6). Snow coverage for late season snowfalls was restricted to high altitudes above 1850m a.s.l. Snow cover from the original snowfalls melted at considerably low rates (<1%/day) below 2800m a.s.l. However, this rate of melt increased significantly to 41%/day at 3450m a.s.l. This considerable increase in the rate of snow dissipation may be a result of strong wind deflation at this altitude after late season snowfalls. An analysis of the daily melt rate of remaining snow cover confirms that increasingly rapid snow dissipation occurs with rising altitude during late season snowfalls that last for between 6 and 10 days (Figure 5.32).

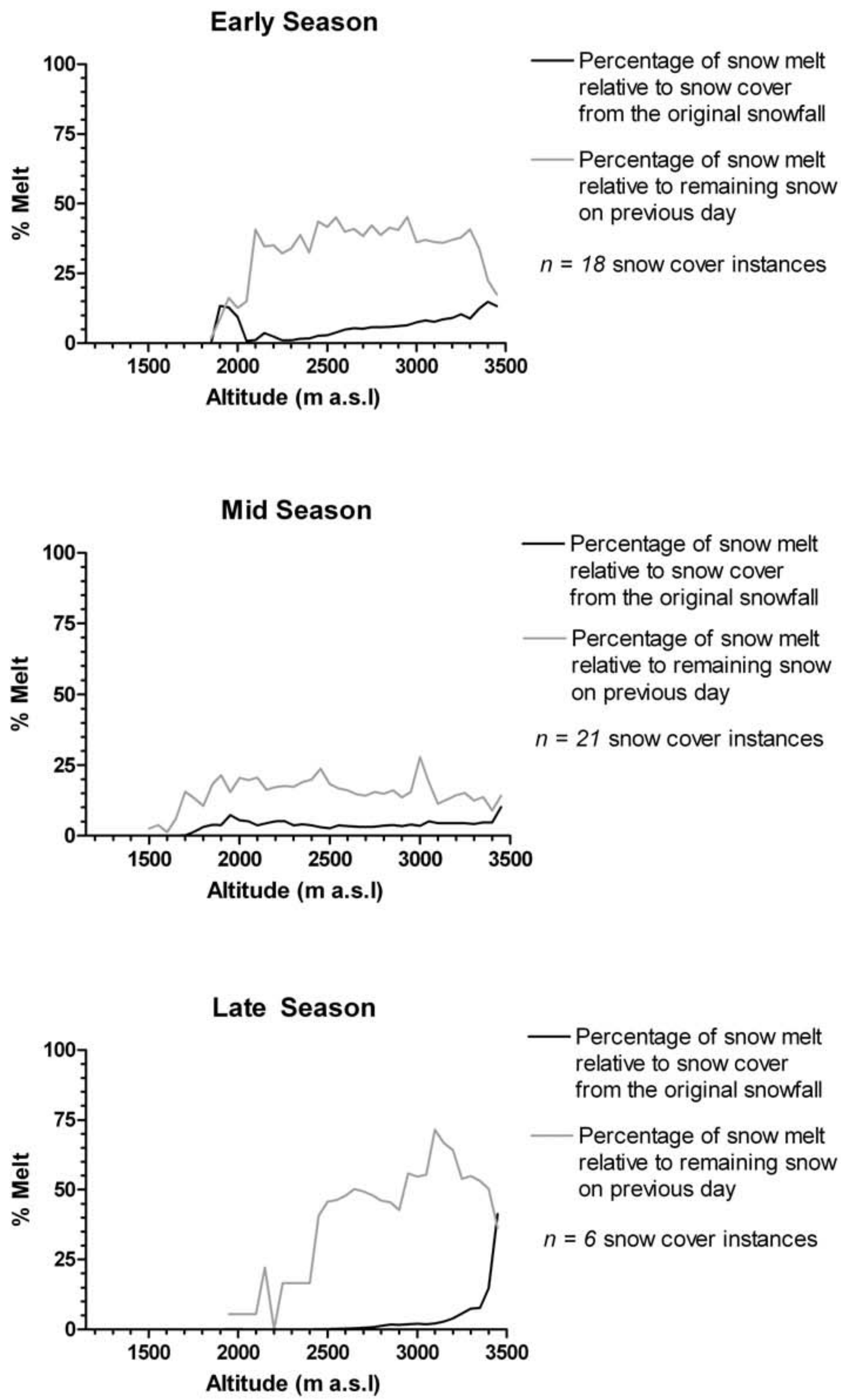

Figure 5.32: Seasonal relationships between mean daily snowmelt and altitude 6 – 10 days after snowfalls.

Table 5.10: Statistical summary of mean daily melt of snowcover from original snowfalls.

		Early Season	Mid Season	Late Season
Mean daily melt (% loss/day)	**1-5 days**	44.81	29.67	34.82
	6-10 days	6.22	3.99	3.10
Standard Deviation	**1-5 days**	20.33	17.72	20.88
	6-10 days	4.17	1.68	7.64
Minimum (% loss/day)	**1-5 days**	26.31	14.35	8.45
	6-10 days	0.01	0.13	0
Maximum (% loss/day)	**1-5 days**	100	79.17	100
	6-10 days	14.85	10.10	41.31

Table 5.11: Statistical summary of mean daily melt of snowcover remaining from the previous day.

		Early Season	Mid Season	Late Season
Mean daily melt (% loss/day)	**1-5 days**	37.65	32.01	46.18
	6-10 days	33.21	15.14	38.41
Standard Deviation	**1-5 days**	9.20	9.65	16.18
	6-10 days	11.24	5.34	20.76
Minimum (% loss/day)	**1-5 days**	12.50	0.76	7.01
	6-10 days	1.96	1.25	0
Maximum (% loss/day)	**1-5 days**	55.98	47.91	65.76
	6-10 days	45.30	27.84	71.46

5.3.5 Daily overview of seasonal snowmelt rates

Seasonal variations in the relationships between the mean daily melt rate and topography (altitude and aspect) from one to nine days after the snowfalls are analyzed at a higher temporal resolution on a daily basis in the following section. Given that snow cover often persists for a short duration, there are few instances of snow cover persisting for longer than 9 days. Therefore, meaningful average daily snowmelt rates presented in this section are limited to 9 daily intervals after the snowfalls.

The comparison between daily rate of snowmelt and altitude 1 day after the snowfalls indicates that melting occurs most rapidly at 1750m a.s.l for all seasons (Figure 5.33). At this altitude, snow cover dissipates fastest during the late season (99%/day), and slowest during the early season (88%/day). The rate of snow cover dissipation during all seasons decreases for altitudes above 2000m a.s.l. However, late season snow cover melts at the slowest rate (30%/day on average) above 2000m a.s.l. This indicates that 1 day after snowfall, snow melts faster at lower altitudes, and at similar rates for early, mid and late season periods. One day after snowfall, snow melts fastest (50%/day) on north-facing slopes and slowest (10%/day) on southern aspects. However, early season snow cover melts most rapidly on south-facing slopes (40%/day), with mid season snow cover dissipating less rapidly (26%/day) at 2000m a.s.l. Late season snow cover melts at the slowest rate on south-facing slopes (9%/day) at 3000m a.s.l. On east-facing and west-facing slopes, late season snow cover dissipates least rapidly at a rate of 40%/day and 30%/day respectively, whilst early season dissipation is 50%/day on average on both aspects (Figure 5.33).

The comparison between altitude and mean daily snowmelt rates for two days after snowfall indicates that the interseasonal rate of snowmelt is similar below 1700m a.s.l (Figure 5.34). However, snow cover melts considerably faster during the late season than for early and mid season snowfalls, with snow cover dissipating by 92% each day on average. The rate of melt during the early and mid season periods remains similar at 30%/day on average between 1700m a.s.l and 3300m a.s.l. Snow cover melts at a relatively low rate at 3450m a.s.l following mid and late season events, whilst the early season snowmelt rate remains at 30%/day. This indicates that snowmelt is relatively independent of altitude during the early and mid season and occurs at a slow rate, however snowmelt occurs quicker in the late season where snow melts fastest below 2200m a.s.l (92%/day). Two days after snowfall, snowmelt is fastest on north-facing slopes for all seasons, but is most rapid during the late season where it dissipates by 81%/day (Figure 5.34). On north-facing slopes, early and mid season snowfalls melt at an equal rate of 33%/day. However, the rate of snowmelt is slowest on south-facing slopes for all seasons, although late season snow cover melts relatively rapidly at a rate of 65%/day on south-facing slopes. Mid season snow cover melts by 25%/day, whilst the early season snowmelt rate is slowest at 16%/day on south-facing aspects. On east-facing slopes, snow cover dissipates most rapidly after late season snowfalls (76%/day) and least rapidly after early season snowfalls (28%/day). This trend coincides with west-facing aspects where snowmelt is most rapid after late season snowfalls (70%/day) and least rapid after early season snowfalls (20%/day).

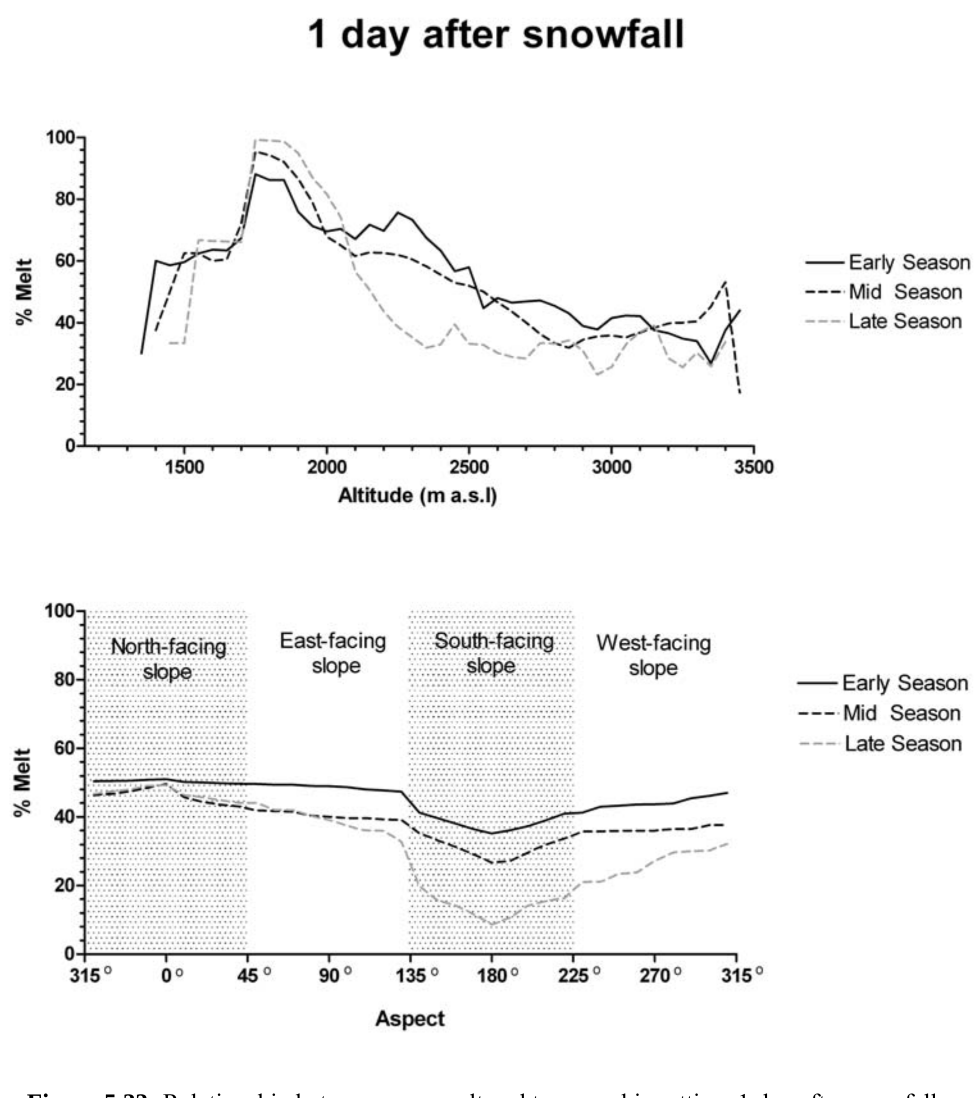

Figure 5.33: Relationship between snowmelt and topographic setting, 1 day after snowfalls.

A comparison between altitude and mean daily snowmelt rates for three days after snowfall indicates that mid season snow cover melts considerably faster above 1850m a.s.l than after early or mid season snowfalls (Figure 5.35). Late season snow cover melts at a maximum rate of 90%/day at 2600m a.s.l. Mid season snow cover remains relatively constant with increasing altitude at a rate of 30%/day < 3300m a.s.l, however the rate of snow dissipation decreases considerably above this altitude to 4%/day. Snowmelt during the early season is most rapid at 2150m a.s.l (45%/day), decreasing to 20%/day on average above 2500m a.s.l. Three days after snowfall, snow melts most rapidly (80%/day) on north-facing slopes (Figure 5.35). Late season snow cover dissipated most rapidly at a rate of 79%/day, whilst early season melt was slowest at only 29%/day. Snowmelt is slowest on south-facing slopes, with early season snow cover melting at a minimum rate of 8%/day. Mid season snow cover dissipated quicker than during the early season, but slower than late season snow cover. On east-facing slopes, snow cover dissipates most rapidly after late season snowfalls (68%/day) and least rapidly after early season snowfalls (24%/day). This trend coincides with west-facing aspects where snowmelt is most rapid after late season snowfalls (64%/day) and least rapid after early season snowfalls (16%/day) (Figure 5.35).

Four days after the snowfalls, snow cover below 2400m a.s.l melts fastest during the late season and reaches a maximum melt rate of 100%/day (Figure 5.36). However, the melt rate of late season snow cover decreases considerably above 2400m a.s.l to 25%/day on average. Mid season snowmelt increases to a maximum rate of 60%/day at 2500m a.s.l, but decreases above this altitude to 30%/day on average. Early season snowmelt follows a similar general trend to the mid season period, although snow cover appears to melt faster (70%/day) at particular altitudinal zones (2500m a.s.l and 3000m a.s.l) than for the mid or late season periods. Snow melt is most rapid during the late season on north-facing slopes (76%/day) and slowest during the early season on south-facing slopes (3%/day) (Figure 5.36). On east-facing slopes, snow cover dissipates most rapidly after late season snowfalls (68%/day) and least rapidly after early season snowfalls (28%/day).

Table 5.12: Statistical comparisons of seasonal variations in the rate of mean daily snowmelt across 48 distinct altitudinal zones.

		Days after snowfalls								
		1	2	3	4	5	6	7	8	9
Early Season	Mean melt rate (% loss/day)	55.60	31.03	25.74	29.26	21.18	17.71	31.08	56.01	45.75
	Median	57.97	31.81	28.72	25.25	25.00	17.09	32.25	57.06	48.57
	Standard Deviation	16.35	7.15	10.27	20.85	14.19	7.09	9.91	13.58	16.46
	Minimum rate (% loss/day)	26.80	8.33	0.00	1.18	0.14	5.61	3.00	18.00	1.33
	Maximum rate (% loss/day)	88.10	44.77	48.63	72.50	50.00	36.01	49.50	79.62	78.93
	Count	43.00	42.00	41.00	32.00	35.00	33.00	32.00	29.00	31.00
Mid Season	Mean melt rate (% loss/day)	53.47	29.03	30.87	34.38	21.63	32.66	9.02	11.85	13.66
	Median	52.40	30.26	33.31	34.69	24.35	33.33	8.04	10.18	14.03
	Standard Deviation	18.15	9.23	11.16	13.71	11.53	15.17	4.78	10.27	6.13
	Minimum rate	17.39	2.56	0.41	3.57	0.00	4.93	1.41	0.00	3.14
	Maximum rate	95.34	46.00	44.15	59.79	42.13	54.76	25.15	38.93	30.59
	Count	42.00	43.00	40.00	37.00	42.00	36.00	40.00	33.00	37.00
Late Season	Mean melt rate (% loss/day)	47.04	57.90	59.72	52.03	48.59	45.97	55.21	58.18	78.77
	Median	34.00	60.49	59.85	44.52	47.30	45.76	50.00	61.52	89.01
	Standard Deviation	23.69	22.89	18.37	31.91	16.30	13.70	17.75	31.43	27.05
	Minimum rate	23.16	0.18	17.61	3.57	8.45	16.67	31.07	1.33	15.48
	Maximum rate	99.31	91.58	89.61	100.00	92.94	66.67	77.44	100.00	100.00
	Count	40.00	39.00	33.00	33.00	27.00	31.00	21.00	8.00	21.00

Table 5.13: Statistical comparisons of seasonal variations in the rate of mean daily snowmelt across 36 distinct aspect classes.

		Days after snowfalls								
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Early Season	**Mean melt rate (% loss/day)**	45.32	24.04	19.10	22.27	14.14	15.15	26.06	19.22	25.10
	Median	47.19	24.28	19.01	24.11	14.44	15.02	23.84	18.05	25.48
	Standard Deviation	4.97	5.82	5.84	9.04	4.47	4.33	5.45	12.16	8.74
	Minimum rate	35.15	14.36	7.62	2.11	3.55	7.44	17.12	2.65	9.18
	Maximum rate	50.93	33.70	28.76	34.67	23.99	23.99	34.38	39.25	42.66
Mid Season	**Mean melt rate (% loss/day)**	38.40	29.41	33.32	37.79	24.32	18.30	13.44	17.89	15.37
	Median	38.35	29.04	33.92	37.99	24.46	19.05	13.69	16.91	16.15
	Standard Deviation	5.96	2.70	8.10	2.99	3.94	4.93	3.83	5.17	3.07
	Minimum rate	26.64	24.90	15.41	29.62	15.73	9.90	6.90	8.38	7.50
	Maximum rate	49.58	33.13	44.45	43.36	33.47	25.02	19.40	27.19	20.22
Late Season	**Mean melt rate (% loss/day)**	31.53	72.51	65.06	64.12	65.79	34.91	36.99	44.89	75.38
	Median	32.45	72.27	64.82	65.52	69.64	35.15	39.14	44.21	78.09
	Standard Deviation	13.02	5.24	6.99	8.45	10.16	8.83	12.55	24.23	13.77
	Minimum rate	8.65	64.79	54.38	45.82	38.64	15.99	12.54	7.84	33.60
	Maximum rate	49.27	81.19	78.77	77.79	80.18	51.18	61.25	88.97	93.83

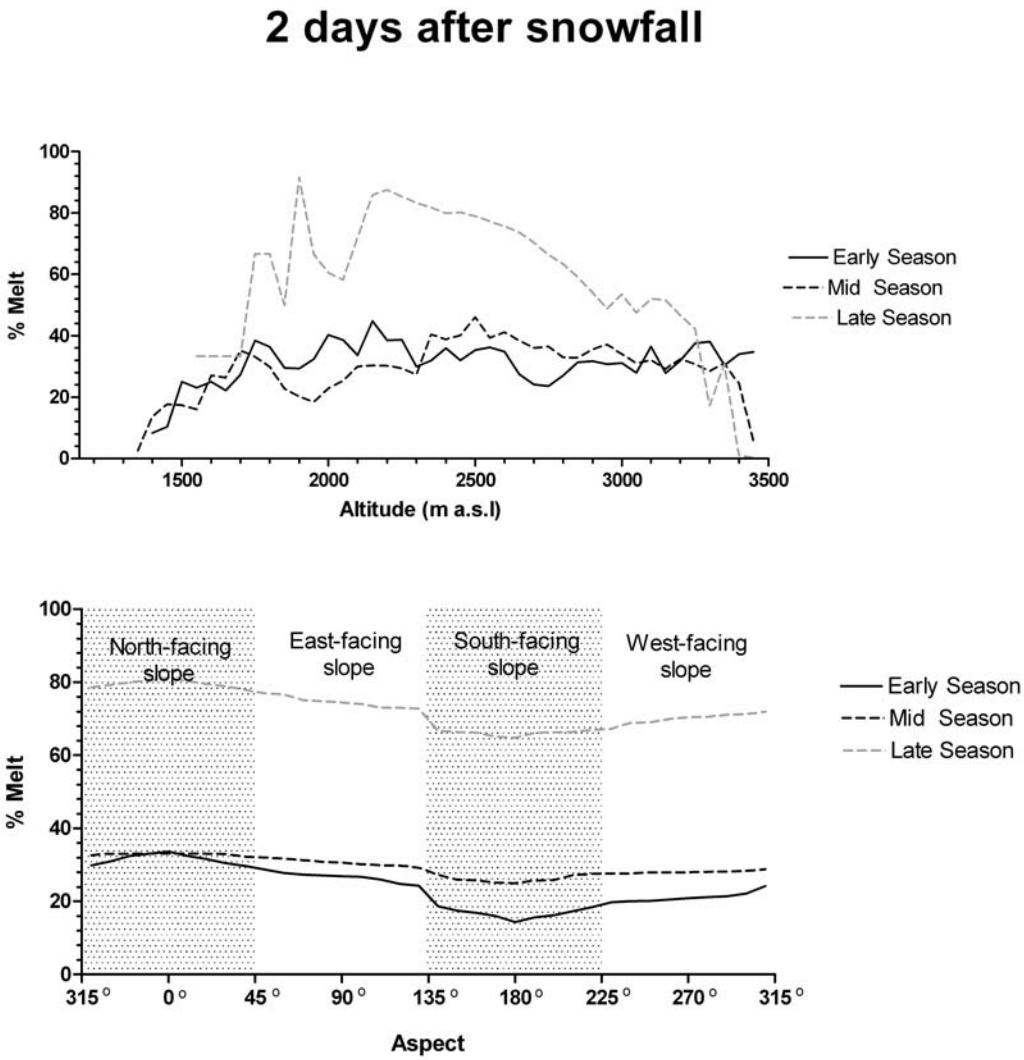

Figure 5.34: Relationship between snowmelt and topographic setting, 2 days after snowfalls.

Five days after the snowfalls, late season snowmelt begins at higher altitudes, where snow cover above 2200m a.s.l melts faster than at a similar altitude after early or mid season snowfalls (Figure 5.37). Early season snowmelt peaks at a rate of 50%/day at 1750m a.s.l, and remains relatively rapid until just below 3000m a.s.l. However, mid season snowmelt increases at a relatively constant rate until 2500m a.s.l, where the rate of snowmelt reaches a maximum of 42%/day. Subsequently, the mid season snowmelt rate decreases steadily with increasing altitude. This indicates that mid season snow cover persists longest above 3000m a.s.l, whilst late season snow cover melts rapidly (80%/day) above this altitude. However, below 3000m a.s.l, mid season snow cover dissipates at a slower rate than during early and late season periods. Five days after the snowfalls, snow cover melts most rapidly on north-facing slopes following late season events by 80%/day, which is considerably higher than for mid (32%/day) and early season (24%/day) snowfalls (Figure 5.37). The early season snowmelt trend is similar to previous comparisons, as snow dissipates slowest on south-facing slopes (4%/day). Following mid season snowfalls, snowmelt patterns indicate slight variation, however the melt rate is highest on north-facing slopes (36%/day) and lowest on south-facing slopes (19%/day). On east-facing slopes, snow cover dissipates most rapidly after late season snowfalls (72%/day) and least rapidly after early season snowfalls (16%/day). This trend coincides with west-facing aspects where snowmelt is most rapid after late season snowfalls (72%/day) and least rapid after early season snowfalls (16%/day). The rate of snow dissipation after mid season snowfalls is 28%/day on both east and west-facing slopes (Figure 5.37).

Six days after snowfalls, snow cover below 2100m a.s.l dissipates fastest during the mid season period, reaching a maximum rate of 67%/day (Figure 5.38). However, the rate of mid season snowmelt decreases at higher altitudes (25%/day at 3000m a.s.l and 6%/day at 3400m a.s.l). The rate of early season snowmelt remains below 30%/day below 2950m a.s.l, but increases above 3000m a.s.l to a maximum rate of 36%/day at 3350m a.s.l. Above 2400m a.s.l, late season snow cover melts faster (40%/day on average) than for both the mid and early season periods. This indicates that 6 days after snowfalls, early season snow cover persists longest < 2400m a.s.l and > 3100m a.s.l. Six days after snowfalls, snow cover dissipates faster on north-facing slopes than on south-facing slopes, for all seasons (Figure 5.38). The rate of late season snowmelt on north-facing slopes is higher than for early or mid season periods, at a maximum rate of 51%/day on average. Snow cover persists longest on south-facing slopes, especially after early season snowfalls, where the snowmelt rate is lowest at 7%/day on average.

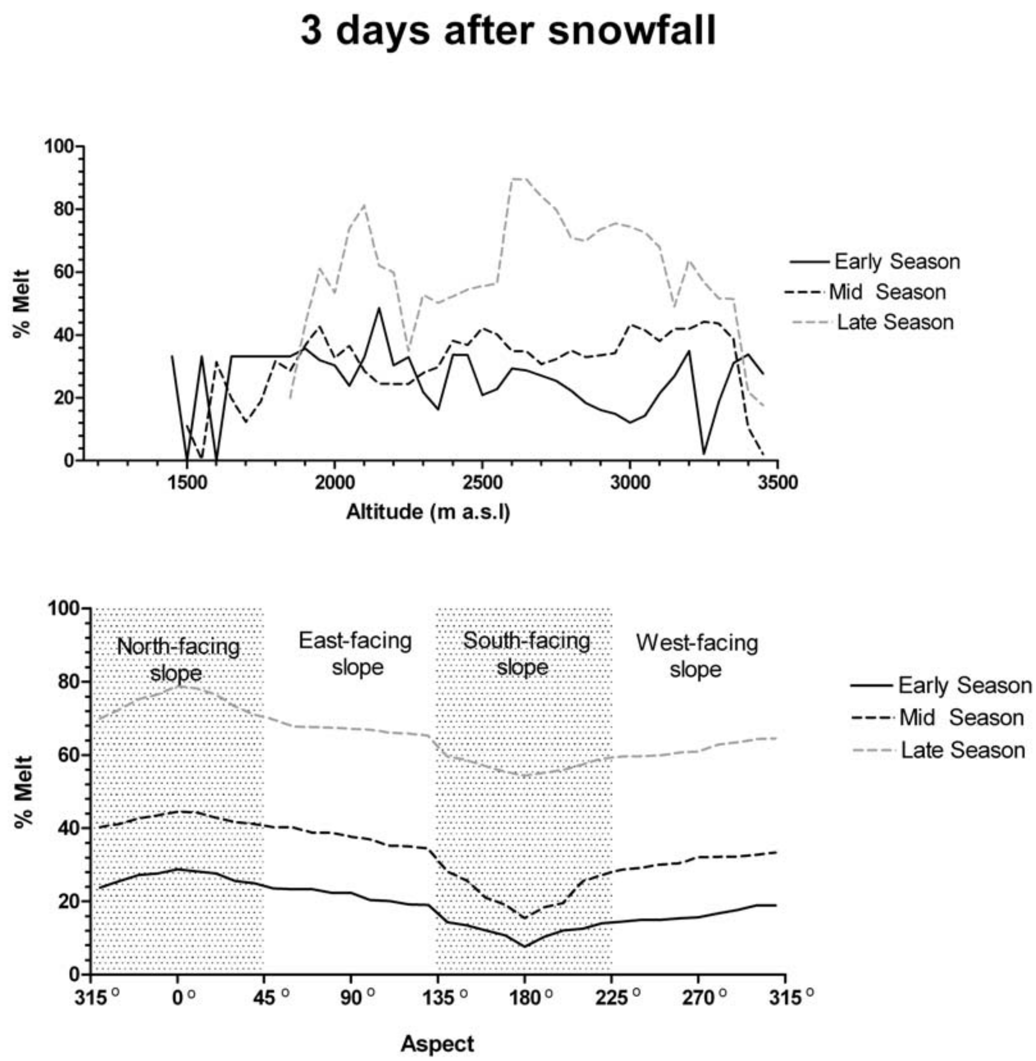

Figure 5.35: Relationship between snowmelt and topographic setting, 3 days after snowfalls.

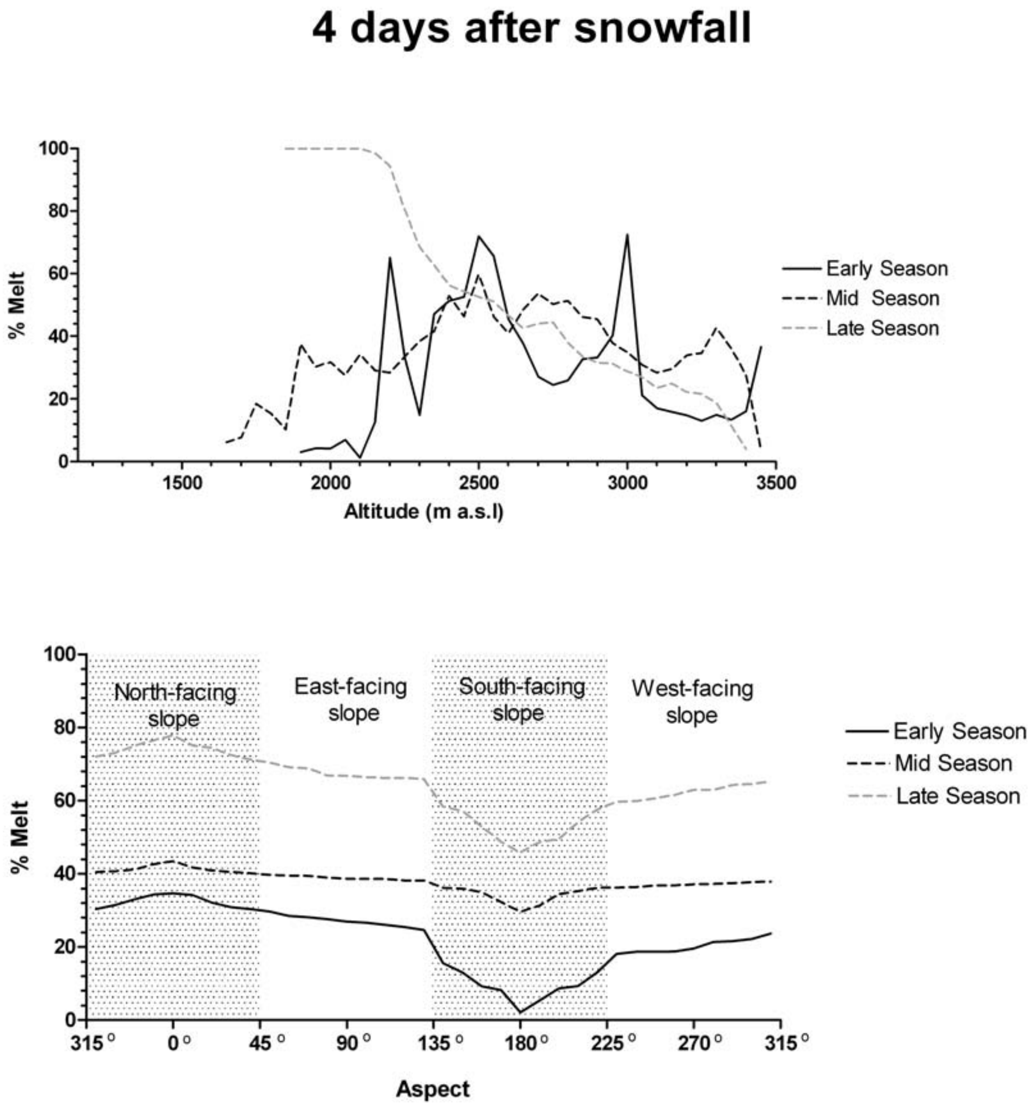

Figure 5.36: Relationship between snowmelt and topographic setting, 4 days after snowfalls.

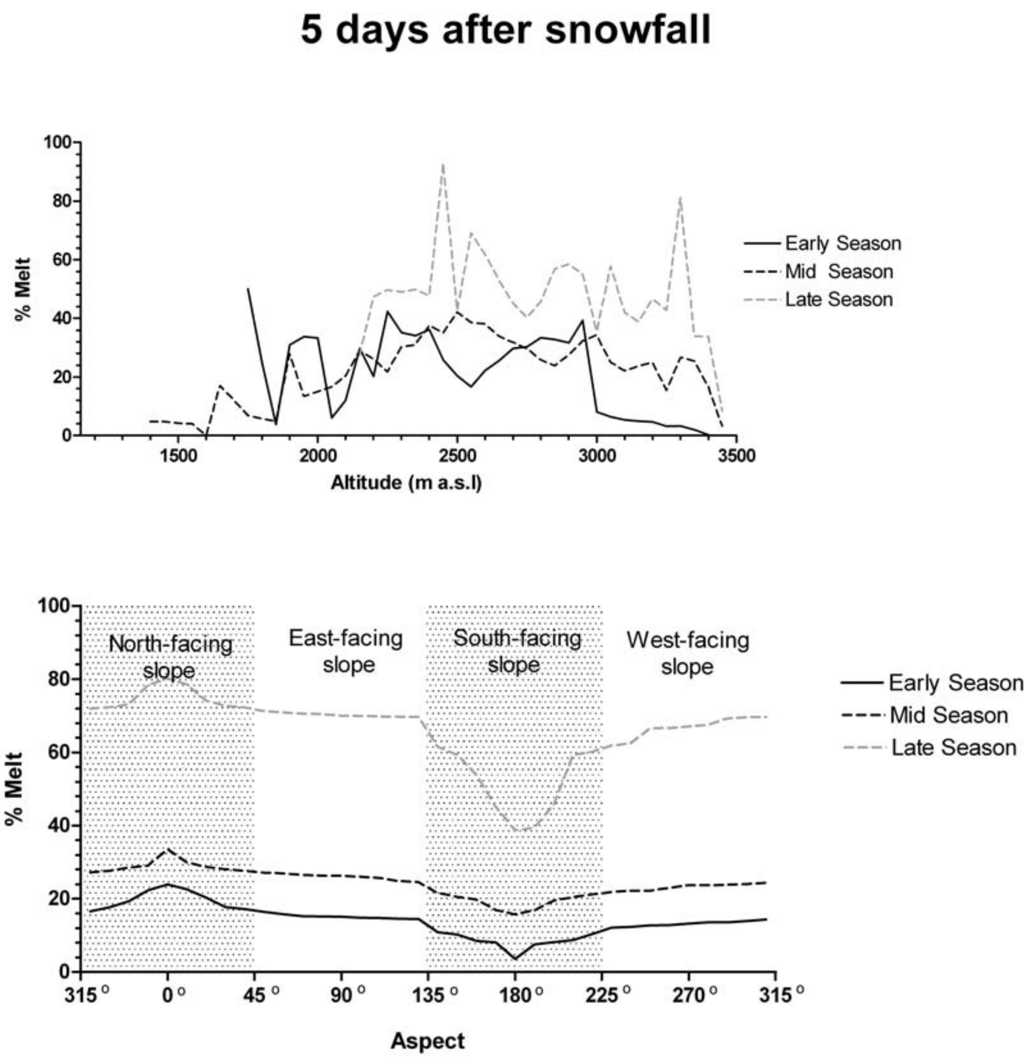

Figure 5.37: Relationship between snowmelt and topographic setting, 5 days after snowfalls.

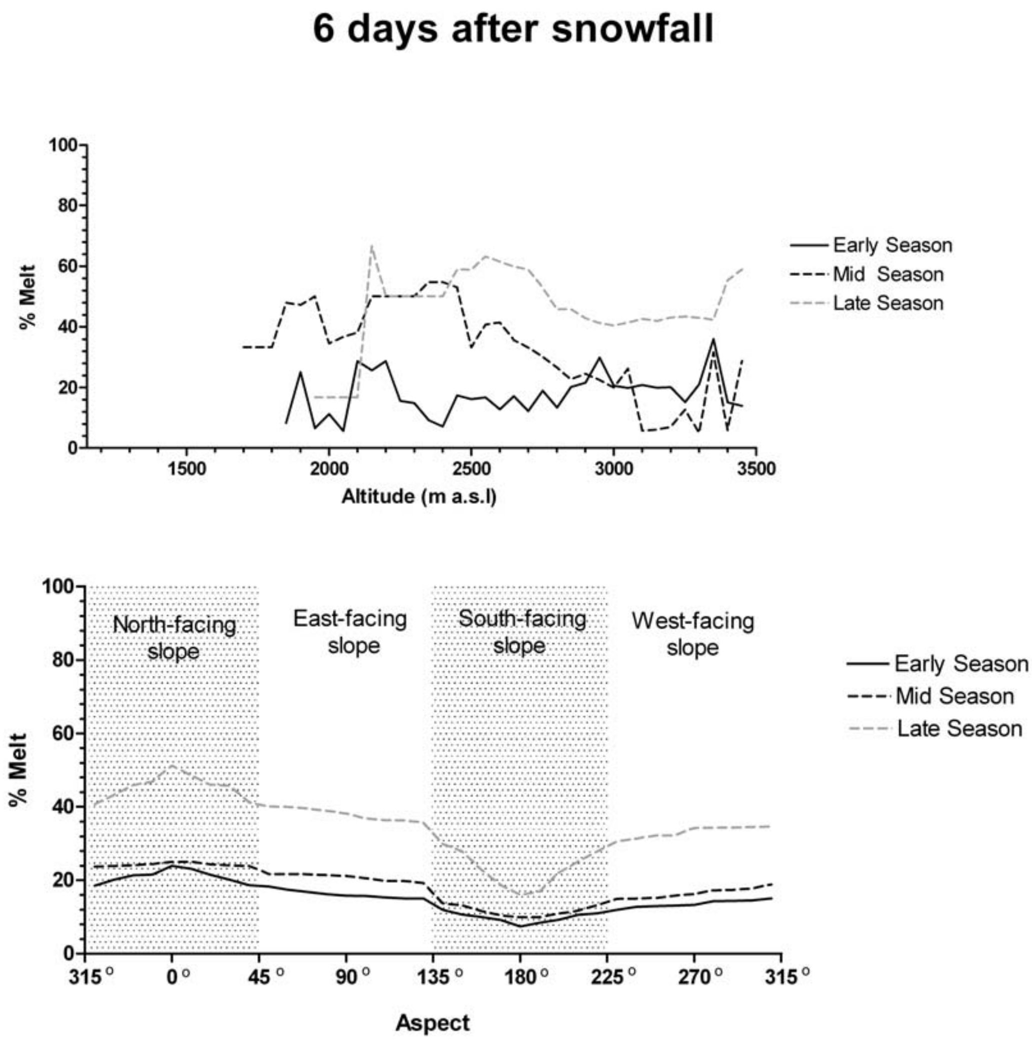

Figure 5.38: Relationship between snowmelt and topographic setting, 6 days after snowfalls.

On east-facing slopes, snow cover dissipates most rapidly six days after late season snowfalls (40%/day) and least rapidly after early season snowfalls (16%/day). This trend coincides with west-facing aspects where snowmelt is most rapid after late season snowfalls (40%/day) and least rapid after early season snowfalls (16%/day). The rate of snow dissipation after mid season snowfalls is 20%/day on both east and west-facing slopes (Figure 5.38).

Seven days after the snowfalls, it is clear that snow cover persists above certain altitudes depending on the season. Mid season snow cover occurs above 1500m a.s.l, and persists for longest as it exhibits the slowest rate of melt (10%/day on average > 2100m a.s.l) (Figure 5.39). Early season snow cover extends above 1950m a.s.l, and melts more rapidly with increasing altitude (36%/day at 2500m a.s.l and 50%/day at 3300m a.s.l). Late season snow cover occurs above 2500m a.s.l, and the rate of dissipation increases rapidly at higher altitudes (36%/day at 2500m a.s.l and 80%/day at 3000m a.s.l). The considerable increase in the rate of snow dissipation above 2500m a.s.l after early and late season snowfalls may be due to strong wind deflation, or increased insolation above 3000m a.s.l especially during the late season period. Seven days after the snowfalls, snow cover melts fastest at high altitudes for early, mid and late season periods. However, snow cover will persist longest during the mid season period. Snowmelt occurs quickest on north-facing slopes, and reaches a maximum rate of melt (60%/day on average) after late season snowfalls (Figure 5.39). However, mid season snow cover melts at the lowest rate (34%/day on average) on north-facing slopes. Snow dissipates least rapidly on south-facing slopes, at a minimum rate of 7%/day on average after mid season snowfalls, and a maximum rate of 17%/day on average after early season snowfalls. On east-facing slopes, snow cover dissipates most rapidly after late season snowfalls (40%/day) and least rapidly after mid season snowfalls (16%/day). This trend coincides with west-facing aspects where snowmelt is most rapid after late season snowfalls (36%/day) and least rapid after mid season snowfalls (16%/day). Snow cover dissipates by 32%/day on east-facing aspects and by 28%/day on west-facing aspects (Figure 5.39).

Eight days after the snowfalls, the most rapid rate of snowmelt occurs above 3100m a.s.l following late season snowfalls, at a maximum rate of 100%/day (Figure 5.40). This is due to the fact that no late season snow cover was recorded below 3100m a.s.l. The rate of snowmelt after early season snowfalls is lower than the late season melt rate, reaching a maximum rate of 78%/day on average at 2450m a.s.l. However, early season snow cover dissipates by 20%/day at 2000m a.s.l and by 76%/day at 2500m a.s.l. This rate decreases above 2500m a.s.l to 48%/day at 3400m a.s.l. Mid season snow cover dissipates at the slowest rate, reaching a maximum of 39%/day on average at 3000m a.s.l.

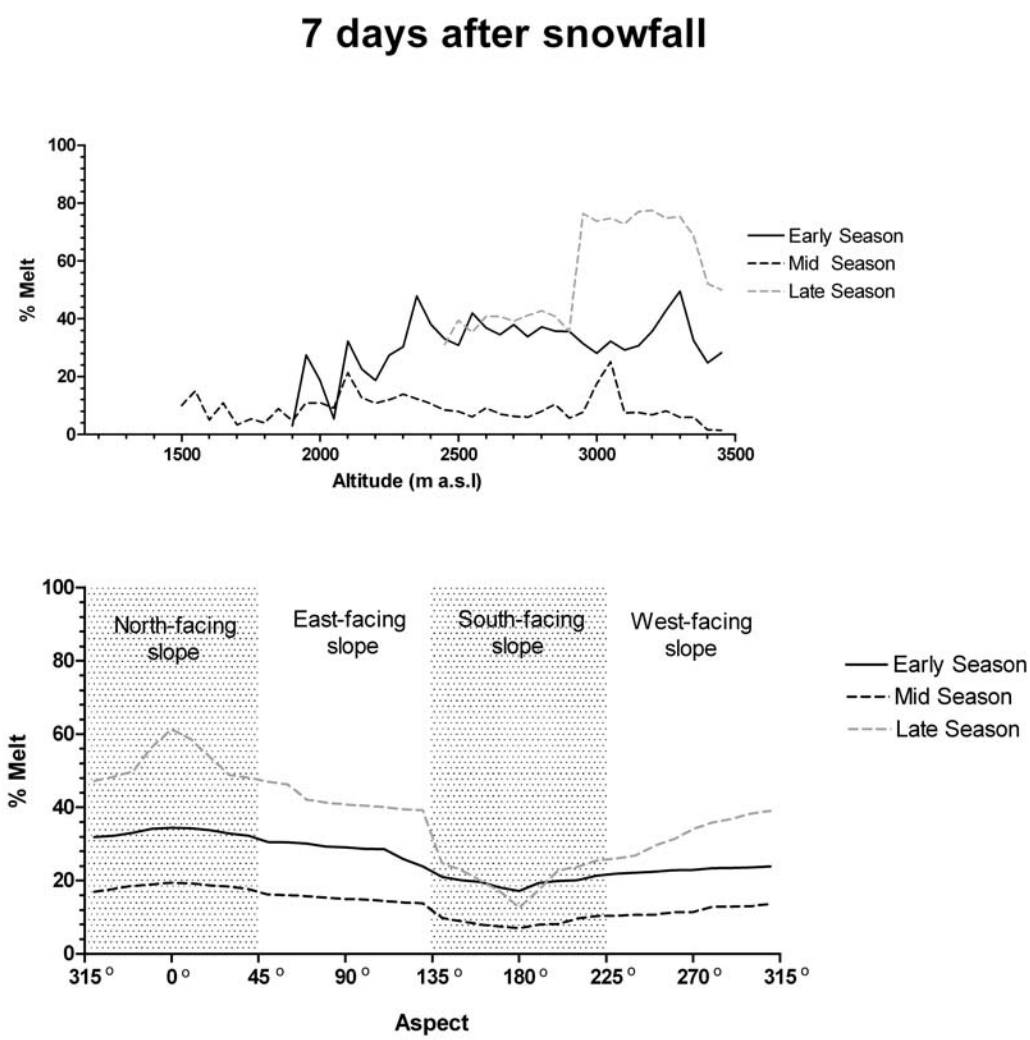

Figure 5.39: Relationship between snowmelt and topographic setting, 7 days after snowfalls.

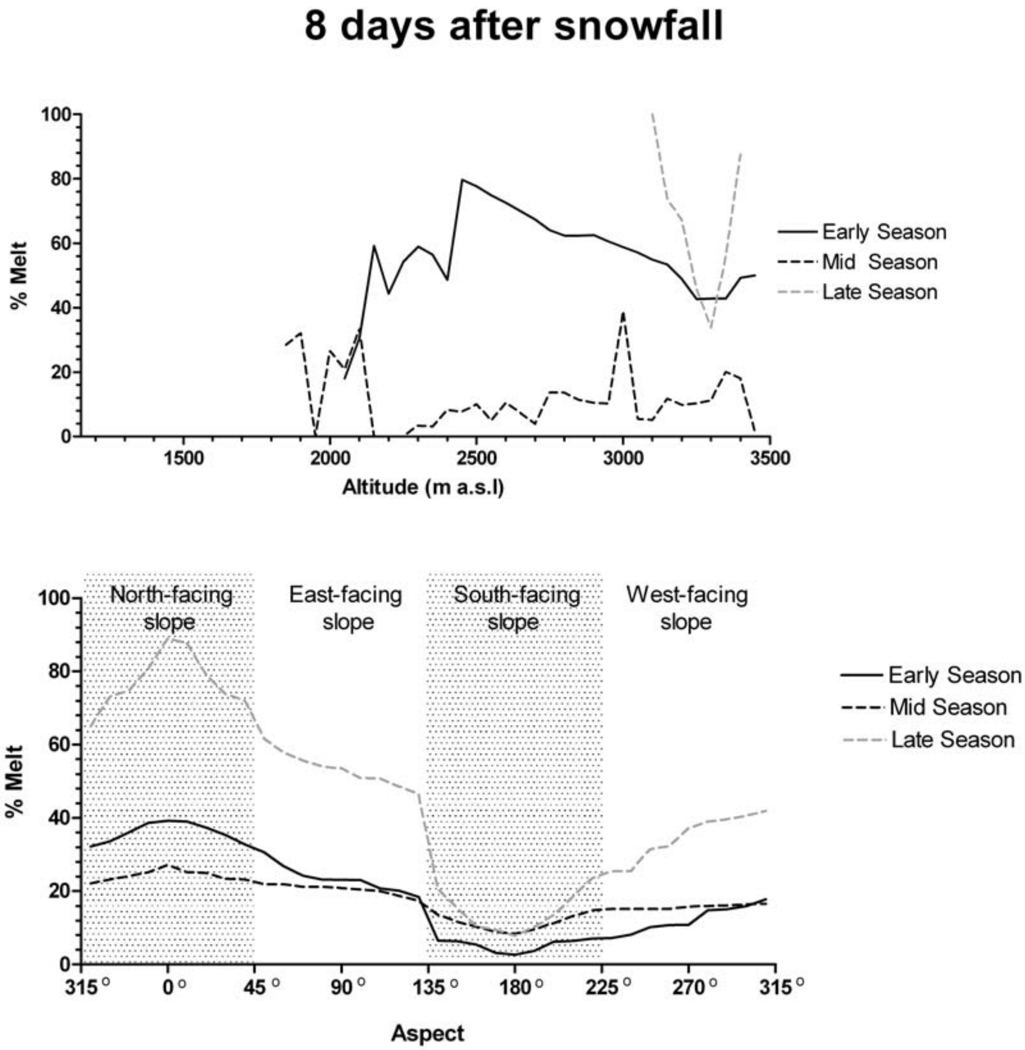

Figure 5.40: Relationship between snowmelt and topographic setting, 8 days after snowfalls.

It is evident that mid season snowfalls occurs at lower altitudes than both early and late season snowfalls. Late season snowfalls are isolated and localized at higher altitudes above 3100m a.s.l. Eight days after snowfalls, no snow cover persists below 1800m a.s.l. The rate of late season snowmelt is considerably higher than the early and mid season rates on north-facing slopes, reaching a peak value of 89%/day on average (Figure 5.40). However, mid season snow cover melts at the lowest rate on north-facing slopes (27%/day on average). On south-facing slopes, mid season and late season snow cover melts at the same rate of 8%/day on average. On south-facing aspects, the slowest rate of snowmelt occurs after early season snowfalls (3%/day). However, on east-facing slopes, snow cover dissipates most rapidly after late season snowfalls (56%/day) and least rapidly after early season snowfalls (24%/day) and mid season snowfalls (20%/day). On west-facing aspects, snowmelt is most rapid after late season snowfalls (40%/day) and least rapid after early season snowfalls (12%/day). Mid season snow cover dissipates slightly more rapidly (16%/day) on west-facing slopes than after early season snowfalls (Figure 5.40).

Nine days after snowfalls, late season snow cover is confined to altitudes between 2450m a.s.l and 3400m a.s.l, and the rate of snowmelt reaches a maximum of 100%/day on average within this zone (Figure 5.41). Early season snow cover melts at a relatively lower rate than late season snow cover, reaching a peak rate of 79%/day at 2950m a.s.l. In contrast, mid season snow cover extends from 1650m a.s.l, and melts at a consistently lower rate of 18%/day on average, even at high altitudes. This indicates that snow cover persists for longer after mid season snowfalls, and occurs at lower altitudes than after early and late season snowfalls. Late season snow cover melts fastest on north-facing slopes, at a maximum rate of 94%/day on average (Figure 5.41). Early season snow cover dissipates slowest on south-facing slopes at a rate of 10%/day on average. Nine days after the snowfalls, mid season snow cover dissipates at the lowest interseasonal rate of 8%/day on average. On east-facing slopes, snow cover dissipates most rapidly after late season snowfalls (84%/day) and least rapidly after mid season snowfalls (16%/day). On west-facing aspects, snowmelt is most rapid after late season snowfalls (92%/day) and least rapid after mid season snowfalls (8%/day). Early season snow cover dissipates by 40%/day on east-facing slopes and by 20%/day on west-facing slopes (Figure 5.41).

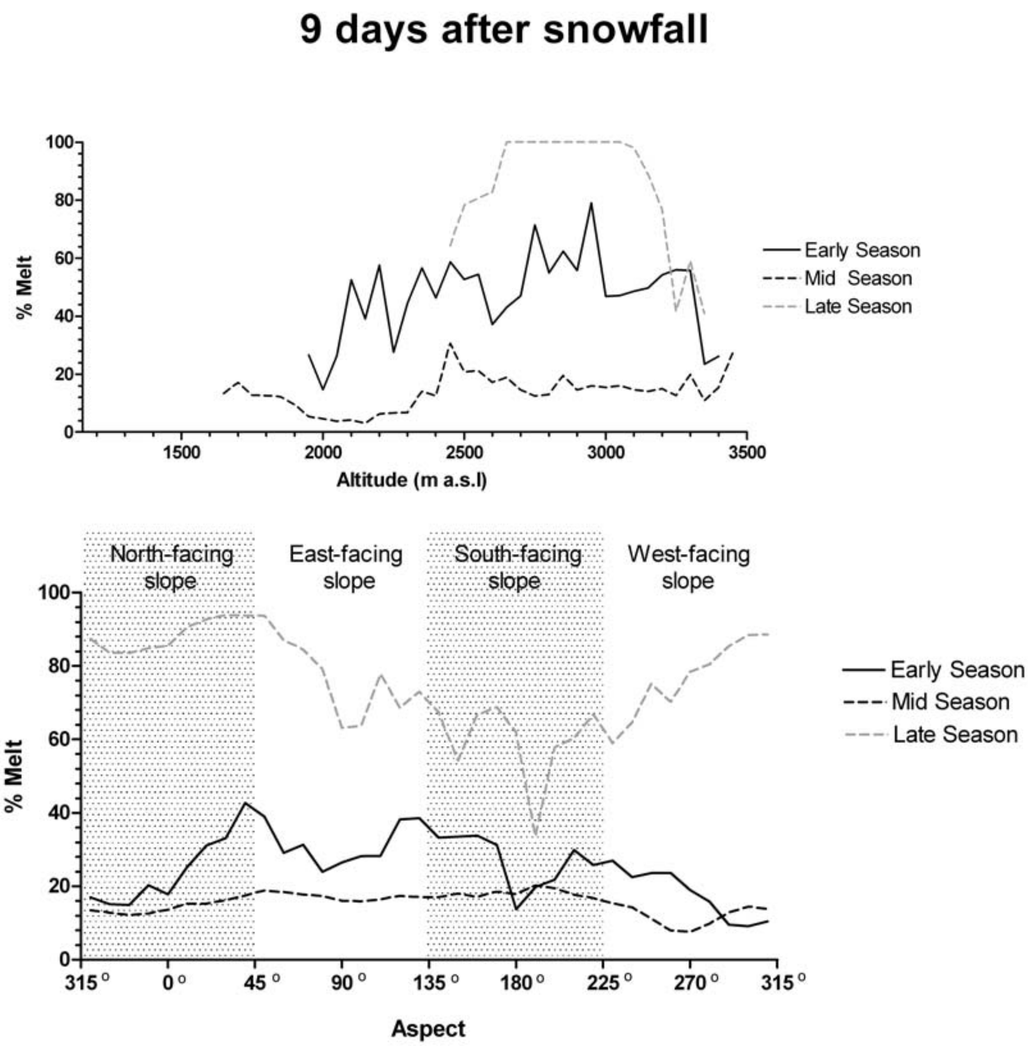

Figure 5.41: Relationship between snowmelt and topographic setting, 9 days after snowfalls.

5.3.6 Satellite mapping of snow cover area

Binary SNOMAP images derived from MODIS 250m-resolution images were created to represent total duration of snow cover, mean duration of snow cover per annum and maximum consecutive days of snow cover, for early, mid and late season snowfalls. These combinations of SNOMAP images reveal distinct spatial and seasonal trends in the duration and location of snow cover. SNOMAP summaries for early season snowfalls indicate that whilst widespread snow cover occurs on the escarpment and all ranges in Lesotho, the majority of such snow cover has a mean duration of less than 5 days per annum (Figure 5.42). Limited snow cover with a mean duration of 6 – 10 days per annum occurs in the Maluti Range and the southern Drakensberg highlands near Quthing, and in localized regions on the Thaba Putsoa Range and eastern escarpment. Early season snow cover with the longest mean duration per annum (11 – 15 days) occurs in considerably isolated patches in the southern Drakensberg highlands. However, the western lowlands and Senqu River Valley remain relatively free from snow throughout the early season period (Figure 5.42). Mid season snow cover is generally more extensive and prolonged than during the early season period (Figure 5.43). Snow cover persisting for 1 – 5 days on average per annum is widespread (9,923 km^2) on all mountain ranges in Lesotho, especially on the escarpment and the Maluti Range. Longer-lasting snow cover (6 – 10 days mean duration per annum) is prevalent to a lesser extent (2,091 km^2), yet occurs extensively on the escarpment near Mokhotlong and Sehlabathebe, as well as in the southern Drakensberg highlands near Quthing. During the mid season period, snow cover with the greatest mean duration per annum (21 – 25 days) occurs in a relatively minor extent (6.7 km^2) on the southern Drakensberg highlands in Quthing district (Figure 5.43). For late season snowfalls occurring during the period 2003 – 2010, the maximum mean duration of snow cover per annum is 1 – 5 days (Figure 5.44). Snow cover is considerably less widespread and less prolonged than after early or mid season snowfalls, and the western half of Lesotho including the Senqu River Valley is free from snow. Late season snow cover is generally absent from the Maluti Range and the Thaba Putsoa Range, however, limited snow patches occur on the Central Range near Qacha's Nek. On average, the majority of late season snow cover is concentrated on the escarpment between Mokhotlong and Sehlabathebe and persists for 1 – 5 days on average per annum (Figure 5.44).

Early season snow cover may be widespread, yet most snow cover persists for a maximum of 1 – 3 days during the period 2003 – 2010 (Figure 5.45). Extensive snow cover is prevalent throughout Lesotho, especially on the escarpment and all mountain ranges. However, the western lowlands and Senqu River Valley remain relatively free from snow after early season snowfalls. However, the maximum duration of snow cover is six consecutive days after early season snowfalls. Isolated and longer-lasting snow patches exist on the escarpment between Mokhotlong and Sehlabathebe, on the Thaba Putsoa Range near Mohale's Hoek, on the Maluti Range, on the Central Range near Qacha's Nek, and in the southern Drakensberg highlands near Quthing and Mount Moorosi, with a maximum of 4 – 6 consecutive days of snow cover during the period 2003 – 2010 (Figure 5.45). Following mid season snowfalls, snow cover is widespread, yet generally short-lived, with most snow covered areas persisting for a maximum of 1 – 3 consecutive days during the period 2003 – 2010 (Figure 5.46). The fragmented appearance of snow cover in the western lowlands is thought to be low-lying cloud cover that has been classified as snow. Mid season snow cover persisting for a maximum of 4 – 6 consecutive days is conspicuous on the escarpment between Mokhotlong and Sehlabathebe, including the ridges of the Maluti Range, Thaba Putsoa Range and the Central Range. Snow cover lasting for a maximum of 10 – 12 consecutive days during the period 2003 – 2010 occurs in fragmented, localized patches along the escarpment, in the Maluti Range, Thaba Putsoa Range and the Central Range, as well as the southern Drakensberg highlands near Quthing. Mid season snow cover persisting longest (maximum of 13 – 15 consecutive days of snow cover) is prevalent mainly in Quthing on the southern Drakensberg highlands, but also occurs in fragmented patches over the Thaba Putsoa Range, the Central Range, and the Maluti Range (Figure 5.46). However, minor patches of isolated snow cover persisting for a maximum of 13 – 15 days occur on the escarpment between Mokhotlong and Sehlabathebe. After late season snowfalls, snow cover persists for a maximum of 1 – 3 consecutive days based on MODIS images for the period 2003 – 2010 (Figure 5.47). During the late season period, the maximum extent of snow cover is less widespread than during the early and mid season periods. The considerably shorter maximum duration of snow cover during the late season period is a result of increasing mean air temperatures and decreasing frequency of snowfalls associated with the onset of warmer climatic conditions.

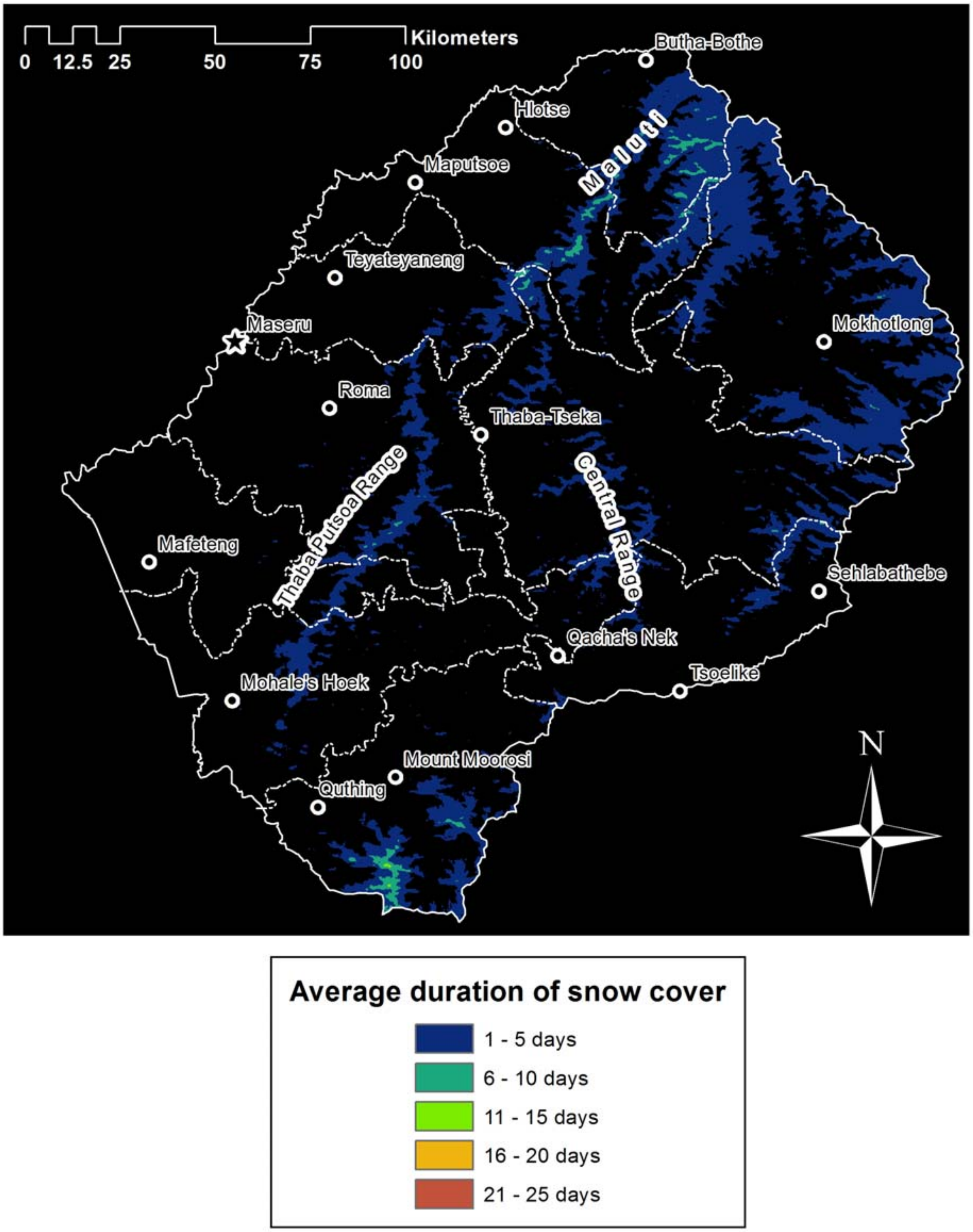

Figure 5.42: Mean duration of snow cover per annual early season for the period 2003 – 2010.

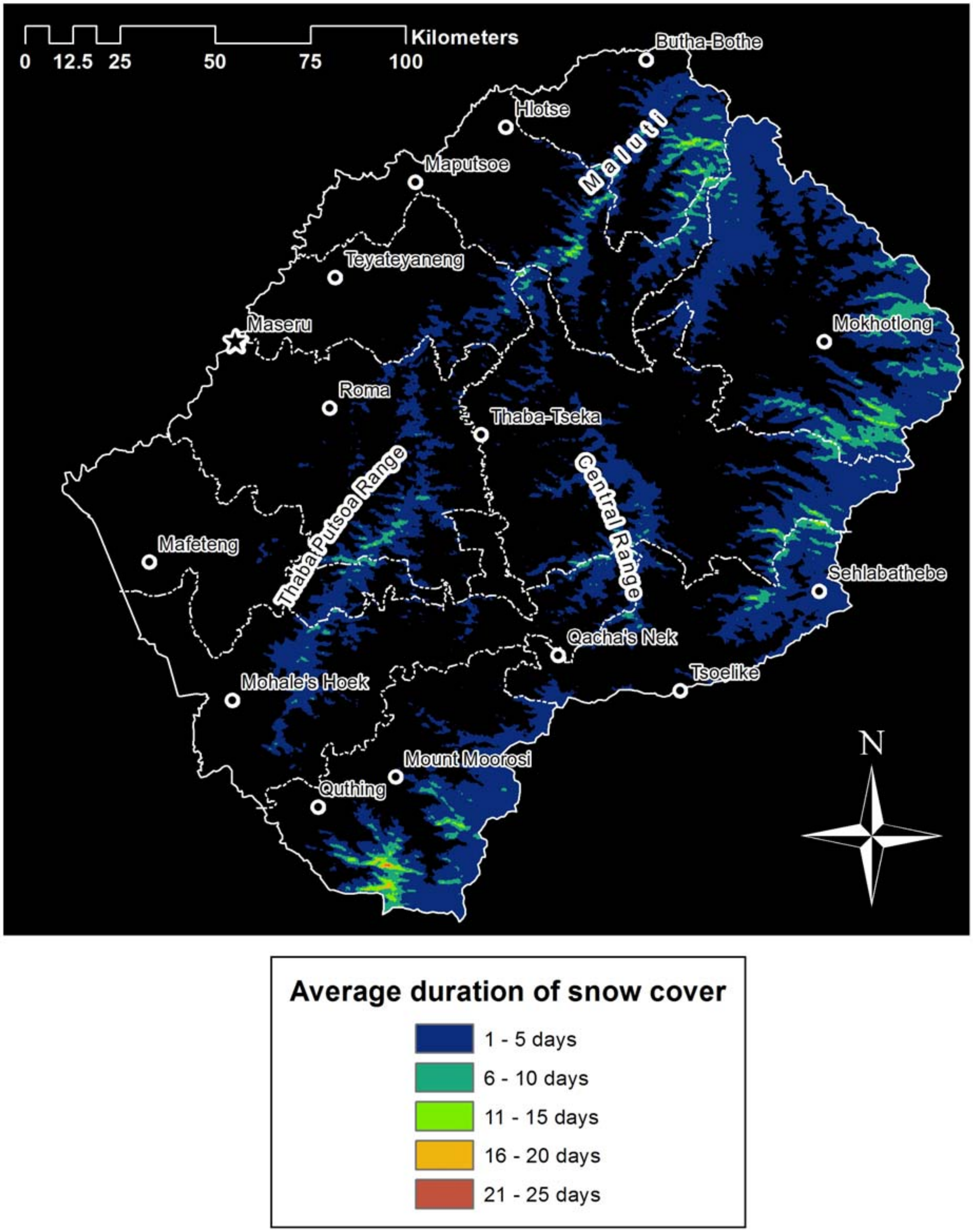

Figure 5.43: Mean duration of snow cover per annual mid season for the period 2003 – 2010.

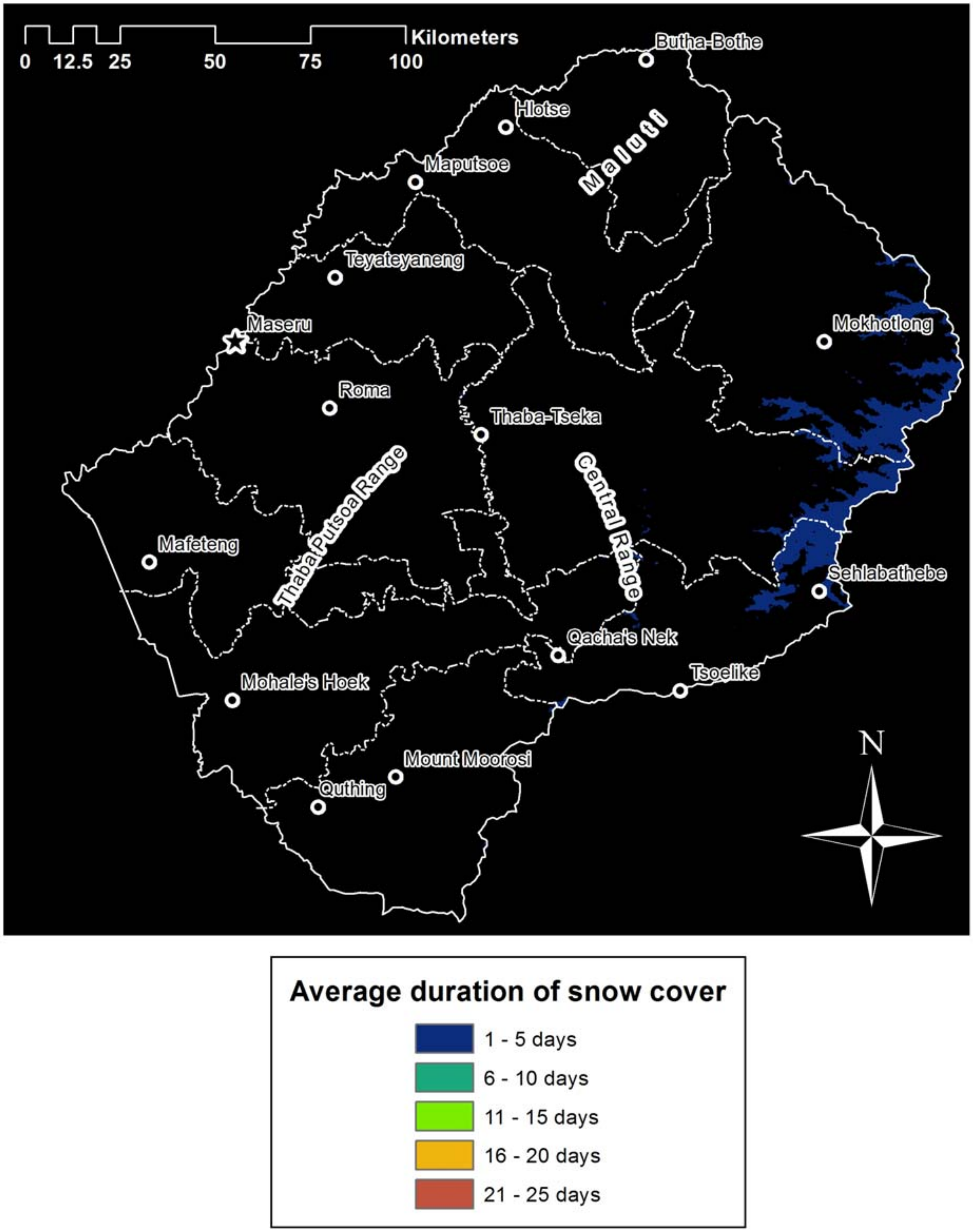

Figure 5.44: Mean duration of snow cover per annual late season for the period 2003 – 2010.

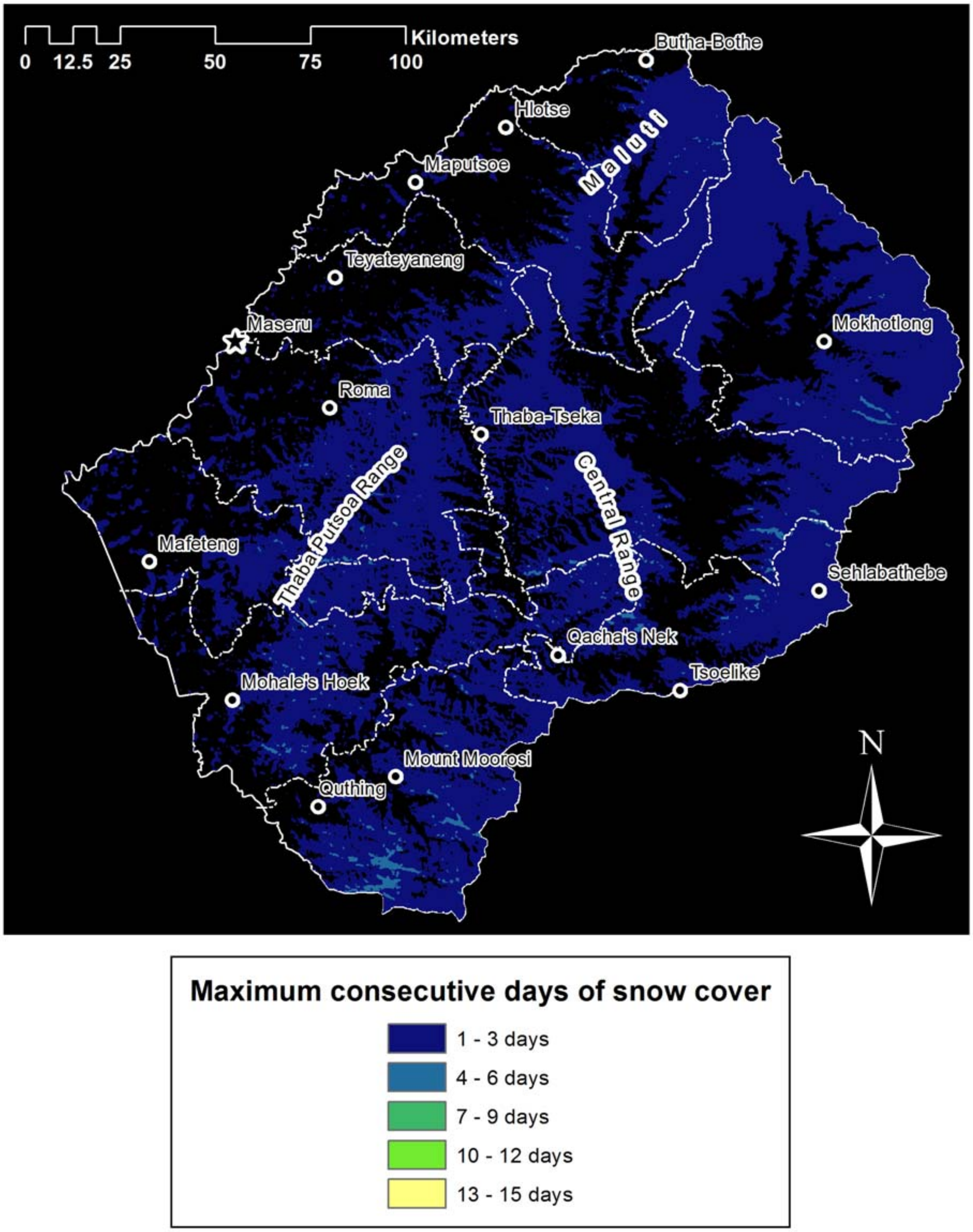

Figure 5.45: Total duration of snow cover for early season snowfalls for the period 2003 – 2010.

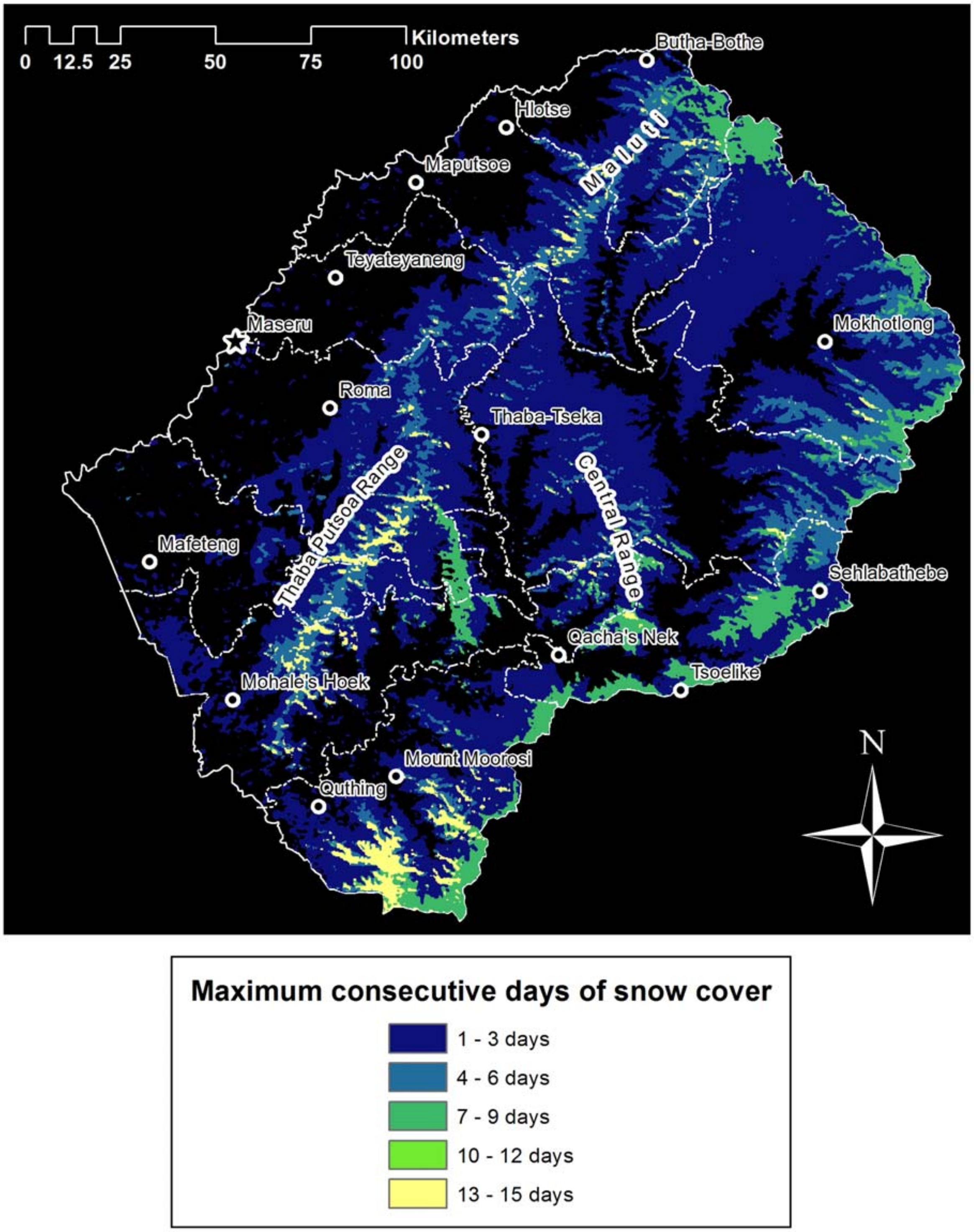

Figure 5.46: Total duration of snow cover for mid season snowfalls for the period 2003 – 2010.

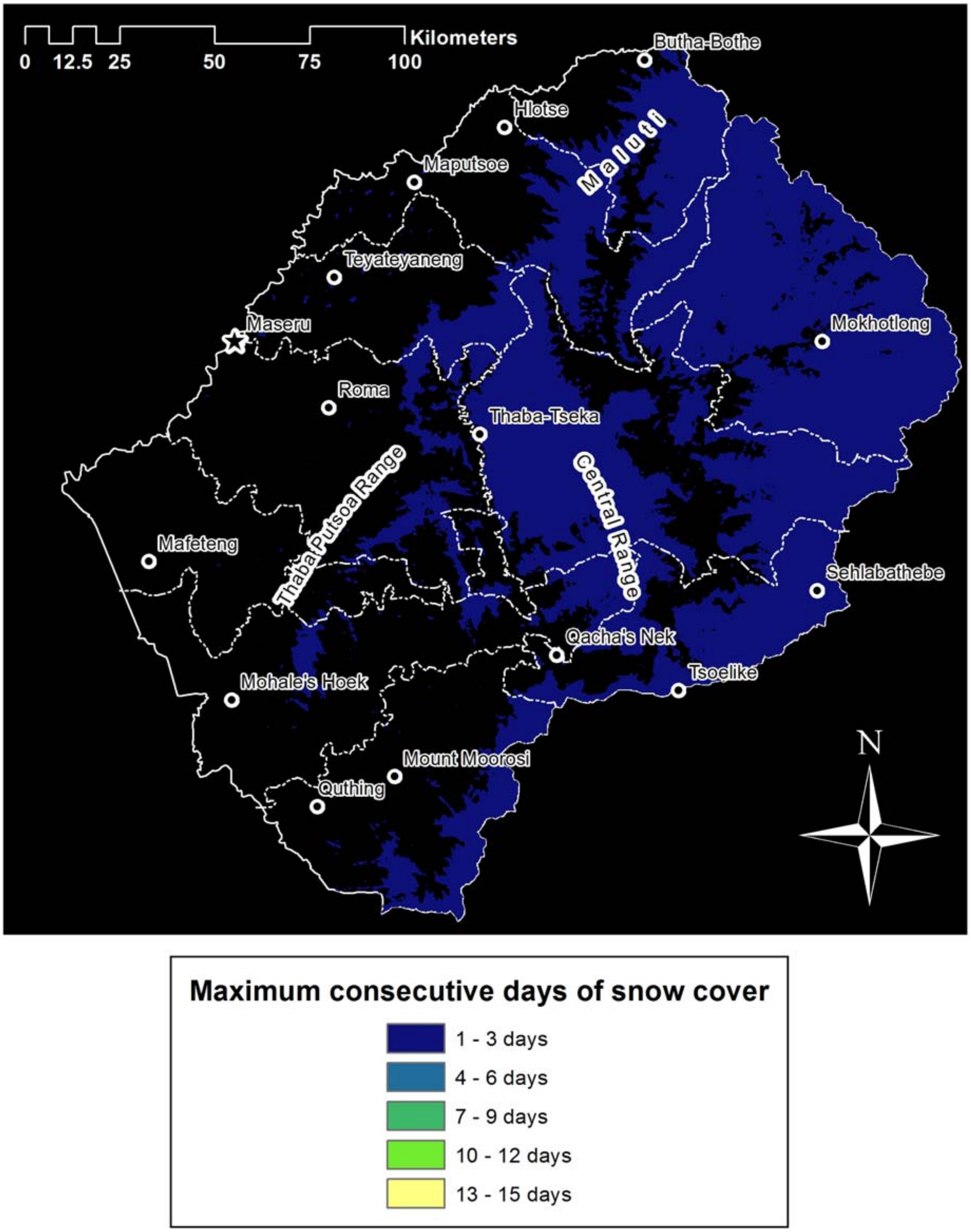

Figure 5.47: Total duration of snow cover for late season snowfalls for the period 2003 – 2010.

5.4 Snow cover and villages

A total of 2016 villages in Lesotho were analyzed according to their proximity to snow cover and accessibility to roads. The extent and duration of snow cover was derived from a sequence of 189 MODIS images for the period 2003 – 2010. The vulnerability of snow-affected villages is expressed in a series of rankings based on 5 vulnerability indicators: the mean number of days of snow cover per annum, the maximum number of consecutive days for the period 2003 – 2010 for which villages are snow bound, proximity to roads, and the mean and maximum duration of snow cover on these roads. Each village was ranked on a scale of 0 – 8 for each of the 5 vulnerability indicators, where 0 represents the lowest risk factor and 8 represents the highest. Finally, an overall vulnerability ranking is assigned to each village, based on the sum of its rankings for the 5 vulnerability indicators. Summaries of the rankings according to the vulnerability indicators are presented in the following section. A detailed list of the individual village rankings is included in Appendix 1.

Table 5.14: Total villages in each district of Lesotho.

District	Villages	% of total (2016)
Berea	153	7.59
Butha-Buthe	104	5.16
Leribe	189	9.38
Mafeteng	208	10.32
Maseru	295	14.63
Mohale's Hoek	307	15.23
Mokhotlong	180	8.93
Qacha's Nek	130	6.45
Quthing	198	9.82
Thaba-Tseka	252	12.50

5.4.1 Proximity and accessibility to roads

The proximity to major and secondary roads is an important indicator of vulnerability, as efficient emergency assistance, evacuation and relief in the event of a disaster is dependent on accessible transport infrastructure. In remote mountainous regions, access to road networks remains even more critical, especially with the risk of severe weather conditions. As the distance between villages and roads increases, vulnerability to the negative impacts associated with isolation rises. The comparison between the number of villages and the proximity to roads reveals that 1009 villages are located within 4.25km of a major road and 874 villages are located within 4.25km of a secondary road (Table 5.15). The number of settlements located further from roads decreases considerably with increasing distance from major and secondary roads. A total of 166 villages are located 12.75 – 17km away from the nearest major road, whilst 26 villages are 25.5 – 29.75km from the nearest major road. Compared with secondary roads, 138 villages are located 12.75 – 17km away from the nearest major road, whilst 15 villages are 25.5 – 29.75km from the nearest secondary road. No villages are located further than 29.75km from the nearest major or secondary road (Table 5.15).

Table 5.15: Proximity of villages to nearest major and secondary roads.

		0-4.25 km	4.25-8.5 km	8.5-12.75 km	12.75–17 km	17-21.25 km	21.25-25.5 km	25.5-29.75 km	29.75-34 km
No. of villages	Distance from major roads	1009	458	227	166	82	48	26	0
	Distance from secondary roads	874	564	289	138	88	48	15	0

The majority of villages are situated nearest to roads that experience a short duration of snow cover (Table 5.16). A total of 2008 villages were classified as having the nearest road covered by snow for a mean of 1 day per annum for the period 2003 – 2010, with 1846 villages having the nearest road covered by snow for a maximum of 1 day for the same period. However, only 16 villages are situated nearest to roads on which snow persists for 2 days on average per annum, with 96 villages having the nearest road covered by snow for a maximum of 2 days. One village had the nearest road covered for 3 days per annum on average, whilst a single village had the nearest road covered for 8 days per annum on average (Table 5.16). However, the nearest roads to considerably more villages have high maximum number of consecutive days of snow cover for the period 2003 – 2010 (Table 5.17). A total of 29 villages had the nearest road covered by snow for a maximum of 3 days, whilst 5 villages had the nearest road snowbound for a maximum of 4 days during this period. A total of 33 villages had the nearest road covered by snow for a maximum of ≥ 8 days.

Table 5.16: Mean consecutive days per annum for which nearest roads are snow covered for the period 2003 - 2010.

	1 day	**2 days**	**3 days**	**4 days**	**5 days**	**6 days**	**7 days**	**≥ 8 days**
Number of villages	2008	6	1	0	0	0	0	1

Table 5.17: Maximum consecutive days for which nearest roads are snow covered for the period 2003 - 2010.

	1 day	**2 days**	**3 days**	**4 days**	**5 days**	**6 days**	**7 days**	**≥ 8 days**
Number of villages	1846	96	29	5	4	3	0	33

5.4.2 Duration of snow cover

A comparison between the number of villages and the total duration of snow cover for the period 2003 – 2010 indicates that 97% of villages in Lesotho experience snow cover that persists for one day or less on average per annum (Table 5.18). A total of 1961 villages are classified as being snow-covered for one day or less on average per annum. However, 9 villages are classified as being snow-covered for 2 days on average per annum. Only 1 village is classified as being snow-covered for 2.5 days on average per annum, whilst 2 villages are classified as being snow-covered for 3.5 days on average per annum. A single village is classified as being snow-covered for ≥ 4 days on average per annum during the period 2003 – 2010 (Table 5.18). The majority of villages (92%) have recorded a maximum of 1 day of consecutive snow cover during the period 2003 – 2010 (Table 5.19). The number of villages experiencing snow cover for more consecutive days decreases considerably beyond a maximum of 1 day, where 97 villages experienced a maximum of 2 consecutive days of snow cover. A total of 5 villages had a maximum of 4 consecutive days of snow cover, whilst 3 villages had a maximum of 6 consecutive days of snow cover. However, 33 villages received a maximum of ≥ 8 days of consecutive snow cover during the period 2003 – 2010 (Table 5.19).

Table 5.18: Villages and mean number of consecutive days of snow cover per annum.

	0.5 day	1 day	1.5 days	2 days	2.5 days	3 days	3.5 days	≥ 4 days
Number of villages	1878	83	42	9	1	0	2	1

Table 5.19: Villages and maximum number of consecutive days of snow cover for the period 2003 – 2010.

	1 day	2 days	3 days	4 days	5 days	6 days	7 days	≥ 8 days
Number of villages	1845	97	29	5	4	3	0	33

5.4.3 Overall vulnerability

The vulnerability for each village in Lesotho was based on 5 vulnerability indicators: the mean number of days of snow cover per annum, the maximum number of consecutive days for the period 2003 – 2010 for which villages are snowbound, proximity to roads, and the mean and maximum duration of snow cover on these roads. Villages were assigned overall vulnerability rankings based on the score obtained for each vulnerability indicator during the early, mid and late season period. Overall vulnerability rankings are represented for each village in Lesotho, as a proportion of the maximum vulnerability ranking of 40 (5 indicators, each with a maximum score of 8). The percentage of villages exposed to snow cover is analyzed according to district and seasonal period. Whilst an appendix of individual village vulnerability rankings forms part of this manuscript (Appendix 1), overall rankings are summarized in this section.

Based on the vulnerability ranking system used in this study, it is evident that the majority of villages in Lesotho have low vulnerability rankings throughout the winter season (Table 5.20). A total of 688 villages (34% of all villages) have a ranking of 1 during the early season, compared with 458 villages (23%) during the mid season and 893 villages (44%) during the late season. However, 116 villages (6%) have a ranking of 5 during the early season, compared with 141 villages (7%) during the mid season and 104 villages (5%) during the late season period. The number of villages with vulnerability rankings of 10 decreases considerably to 5 villages (0.25%) during the early season, 27 villages (1.34%) during the mid season and none during the late season period. During the early season period, only Anone (Quthing) had a vulnerability ranking of 15, compared with Ha Raninni (Mafeteng), Letseng (Mohale's Hoek), Liteleng and Mohlanapeng (Butha – Buthe) in the mid season period. Only one village, Thoteng (Butha-Buthe) has the highest vulnerability ranking (18), in the mid season period. It is evident that during the early and late season periods, the majority of villages have a low vulnerability ranking (1). However, during the mid season period, fewer villages are ranked as 1, with higher numbers of villages with increased vulnerability rankings than during early and late season. Most settlements in Lesotho are affected by snow during the mid season (1987 villages, 98.5% of total), compared with the early season (1974 villages, 97.9% of total) and late season (1971 villages, 97.7% of total) periods (Table 5.20).

Table 5.20: Numbers of villages classified by seasonal vulnerability ranking. Bracketed figures represent villages as a percentage of the total village database (2016 villages).

Vulnerability Ranking	Early Season	Mid Season	Late Season
1	688 (34%)	458 (23%)	893 (44%)
2	378 (19%)	492 (24%)	332 (16%)
3	382 (19%)	414 (21%)	274 (14%)
4	259 (13%)	270 (13%)	240 (12%)
5	116 (6%)	141 (7%)	104 (5%)
6	75 (4%)	68 (3%)	69 (3%)
7	26 (1.29%)	35 (1.74%)	39 (1.93%)
8	23 (1.14%)	22 (1.09%)	14 (0.69%)
9	10 (0.5%)	25 (1.24%)	6 (0.3%)
10	5 (0.25%)	27 (1.34%)	0
11	6 (0.3%)	16 (0.79%)	0
12	4 (0.2%)	6 (0.3%)	0
13	0	4 (0.2%)	0
14	1 (0.05%)	2 (0.1%)	0
15	1 (0.05%)	4 (0.2%)	0
16	0	2 (0.1%)	0
17	0	0	0
18	0	1 (0.05%)	0
Total	**1974 (97.9%)**	**1987 (98.5%)**	**1971 (97.7%)**

It has been established that Anone (Quthing) has the highest early season vulnerability ranking (15), however Aupolosi (Mokhotlong) has a slightly lower vulnerability ranking of 14 (Table 5.21). In a summary of the 10 highest-ranked villages, Liteleng (Butha-Buthe), Setleketseng (Butha-Buthe), Thaba-Khubelu (Mokhotlong) and Thopo (Butha-Buthe) share a vulnerability ranking of 12. During the mid season period, the highest-ranked village is Thoteng (Butha-Buthe) with a vulnerability ranking of 18 (Table 5.22). The second highest ranked villages are Letseng-la-Terae (Mokhotlong) and Mabalane (Butha-Buthe), which share a vulnerability ranking of 16. Four settlements have a mid season vulnerability ranking of 15, namely Liteleng (Butha-Buthe), Ha Rannini (Mafeteng), Letseng (Mohale's Hoek) and Mohlanapeng (Butha-Buthe). Notably, the village of Liteleng (Butha-Buthe) is among the 10 highest-ranked settlements for both the early and mid season periods. However, the 10 highest-ranked villages for the late season period have considerably lower rankings than both early and mid season perods (Table

5.23). The villages with the highest late season vulnerability ranking (9) are Liphaleng (Leribe), Lithipeng (Mohale's Hoek), Khotojieng (Thaba-Tseka), Likonyeleng (Qacha's Nek) and Ha Mashenephe (Quthing).

Table 5.21: Villages with the 10 highest vulnerability rankings during the early season period.

Village	District	Vulnerability Ranking
Anone	Quthing	15
Aupolasi	Mokhotlong	14
Liteleng	Butha-Buthe	12
Setleketseng	Butha-Buthe	12
Thaba-Khubelu	Mokhotlong	12
Thopo	Butha-Buthe	12
Bolula	Mokhotlong	11
Ha Makepe	Mokhotlong	11
Ha Matsumunyane	Leribe	11
Ha Ranqhongoana	Mokhotlong	11

Table 5.22: Villages with the 10 highest vulnerability rankings during the mid season period.

Village	District	Vulnerability Ranking
Thoteng	Butha-Buthe	18
Letseng-la-Terae	Mokhotlong	16
Mabalane	Butha-Buthe	16
Liteleng	Butha-Buthe	15
Ha Rannini	Mafeteng	15
Letseng	Mohale's Hoek	15
Mohlanapeng	Butha-Buthe	15
Bahaoleng	Thaba-Tseka	14
Ha Kanono	Mokhotlong	14
Liqalaneng	Butha-Buthe	13

Table 5.23: Villages with the 10 highest vulnerability rankings during the late season period.

Village	District	Vulnerability Ranking
Liphaleng	Leribe	9
Lithipeng	Mohale's Hoek	9
Khotojieng	Thaba-Tseka	9
Likonyeleng	Qacha's Nek	9
Ha Mashenephe	Quthing	9
Kopanong	Berea	9
Tsieng	Maseru	8
Matsabeng	Mokhotlong	8
Lehlakaneng	Butha-Buthe	8
Lumang	Thaba-Tseka	8

A comparison of the number of villages at specific aspects and altitudinal zones indicates that settlements are located on predominantly north-facing slopes between 1400 – 2700m a.s.l (Table 5.24). The most populated topographic setting is 1700 – 1800m a.s.l on north-facing slopes, with a total of 108 villages. East-facing slopes are less favoured than north-facing aspects, although most villages on east-facing slopes (99%) are also located between 1400 – 2700m a.s.l. West-facing aspects have generally fewer villages (347) than north- (831) and east-facing slopes (636), but more than south-facing slopes which have the least villages between 1400 – 2700m a.s.l (202). Only 3 villages are located above 2700m a.s.l, an unnamed village (Butha-Buthe) on a north-facing slope between 2700 – 2800m a.s.l, Ha Rannini (Mafeteng) on a west-facing slope between 2800 – 2900m a.s.l, and Letseng-la-Terae (Mokhotlong) on a north-facing slope between 3000 – 3100m a.s.l.

The number of villages at specific aspects and altitudinal zones is compared with the percentage of villages affected by snow cover each year (Table 5.24). The percentage of villages experiencing snow cover each year is higher on west-facing slopes than on north-facing slopes at all altitudes < 2600m a.s.l. On south-facing slopes, the percentage of villages experiencing snow cover each year is higher than on north-facing slopes except for 1500 – 1600m a.s.l and 2300 – 2400m a.s.l. The percentage of villages experiencing snow cover each year is also higher on east-facing slopes than on north-facing slopes, except for 1400 – 1500m a.s.l, 2200 – 2300m a.s.l and 2600 – 2700m a.s.l.

Table 5.24: Number of villages at specific altitudes and slope aspects. Bracketed figures represent the percentage of villages affected by snow each year.

Altitudinal Zone	Aspect			
	North-facing	**East-facing**	**South-facing**	**West-facing**
1100-1200m a.s.l	0	0	0	0
1200-1300m a.s.l	0	0	0	0
1300-1400m a.s.l	0	0	0	0
1400-1500m a.s.l	20 (55%)	17 (41%)	5 (60%)	3 (67%)
1500-1600m a.s.l	75 (45%)	74 (42%)	36 (42%)	27 (63%)
1600-1700m a.s.l	101 (35%)	95 (49%)	44 (50%)	63 (59%)
1700-1800m a.s.l	108 (47%)	76 (51%)	30 (60%)	47 (51%)
1800-1900m a.s.l	99 (43%)	73 (59%)	21 (57%)	49 (57%)
1900-2000m a.s.l	65 (57%)	46 (65%)	13 (69%)	30 (57%)
2000-2100m a.s.l	40 (50%)	35 (71%)	4 (50%)	12 (67%)
2100-2200m a.s.l	48 (56%)	45 (64%)	8 (75%)	17 (82%)
2200-2300m a.s.l	83 (48%)	77 (38%)	15 (60%)	35 (63%)
2300-2400m a.s.l	82 (48%)	51 (53%)	17 (47%)	27 (74%)
2400-2500m a.s.l	63 (51%)	32 (69%)	5 (100%)	20 (85%)
2500-2600m a.s.l	33 (55%)	8 (63%)	3 (100%)	11 (73%)
2600-2700m a.s.l	13 (54%)	6 (50%)	1(100%)	5 (40%)
2700-2800m a.s.l	0	1 (100%)	0	0
2800-2900m a.s.l	0	0	0	1 (100%)
2900-3000m a.s.l	0	0	0	0
3000-3100m a.s.l	1 (100%)	0	0	0
3100-3200m a.s.l	0	0	0	0
3200-3300m a.s.l	0	0	0	0
3300-3400m a.s.l	0	0	0	0
>3400m a.s.l	0	0	0	0

5.4.4 Spatial relationships between villages and vulnerability

The overall vulnerability rankings assigned to villages in Lesotho were integrated with digital maps and elevation data by means of a GIS. In this manner, the spatial location of each village may be compared with topography, road access and overall vulnerability for early, mid and late season snowfalls. The location of major and secondary roads is included for spatial comparison between villages and road networks. Whilst the spatial dynamics of seasonal village vulnerability is summarized in this section, detailed regional maps indicating vulnerability for each village are presented in Appendix 2. It has been established that most villages in Lesotho are located below 2000m a.s.l (Table 5.24), and are concentrated in the western lowlands and the Senqu River Valley (Figure 5.48). Highlands and ridges of all mountain ranges above 2500m a.s.l are generally uninhabited, although 43 villages are located above this altitude in Mokhotlong, Butha-Buthe, Thaba-Tseka, Qacha's Nek and Quthing (Table 5.24). Therefore, the majority of villages exhibit low vulnerability to the negative impacts associated with prolonged snow cover, because the lowlands experience snowfalls less frequently than the highlands, and resulting snow cover dissipates rapidly. However, based on topographic maps of villages and transport routes, several major roads traverse high-lying terrain in the Maluti Range (>3000m a.s.l), the Thaba Putsoa Range (>2500m a.s.l) and the Central Range (>2500m a.s.l) (eg. Figure 5.48). Secondary roads are located on mountainous terrain in the Central Range (>2500m a.s.l) and on the escarpment south of Mokhotlong (>3000m a.s.l). Therefore, villages and towns connected by such high-lying major and secondary roads are vulnerable to isolation if these roads are snowbound for extended periods.

Following early season snowfalls, 1823 villages (91%) have vulnerability rankings of 1 – 5 (Table 5.20), which is evident in the spatial comparison of early season vulnerability (Figure 5.48). A total of 139 villages (7.18%) have vulnerability rankings of 6 – 10 during the early season period. Only 12 villages (0.6%) have vulnerability rankings greater than 10. The village of Anone in the southern Drakensberg highlands near Quthing has the highest early season vulnerability ranking of 15, and is located at 1650 –

1700m a.s.l. The village of Aupolasi in central Mokhotlong has the second-highest early season vulnerability ranking of 14, and is located at 1750 – 1800m a.s.l. The 10 highest-ranked villages during the early season period are located in Mokhotlong, Butha-Buthe, Leribe and Quthing (Table 5.21), which are provinces with extensive mountainous terrain (Figure 5.48). However the village of Ha Matsumunyane in Leribe, southeast of Hlotse is located below 2000m a.s.l, yet has an early season vulnerability ranking of 11 due to the frequency of snowfalls in the adjoining Maluti Range.

After mid season snowfalls, 1775 villages (88%) have vulnerability rankings of 1 – 5 (Table 5.20), which is evident in the spatial comparison of mid season vulnerability (Figure 5.49). A total of 177 villages (8.78%) have vulnerability rankings of 6 – 10 during the mid season period, whilst 35 villages (1.74%) have vulnerability rankings greater than 10. It is evident that villages classified with relatively higher mid season vulnerability rankings (>10) are adjacent to mountain ranges and high-lying regions, noticibly the northern intersection between the Thaba Putsoa and Central Ranges, the Maluti Range, the escarpment between Mokhotlong and Sehlabathebe, and the southern Drakensberg highlands in Qacha's Nek and Quthing (Figure 5.49). The village of Thoteng (Butha-Buthe) in the Maluti Range at an altitude of 2250 – 2300m a.s.l, and has the highest vulnerability ranking (18) of all villages throughout winter. In the same valley is the village Mabalane, which has a rank of 16, and Liteleng and Mohlanapeng, which have vulnerability rankings of 15. Letseng-la-Terae lies to the southeast in Mokhotlong, and has a vulnerability ranking of 16. Ha Rannini (Mafeteng) and Letseng (Mohale's Hoek) have vulnerability rankings of 15. Several villages near the escarpment in Mokhotlong have relatively higher mid season vulnerability rankings: Ha Kanono (14), Ha Letsie (12), Ha Mosiuoa (11) and Limapong (11).

It has been established that late season snowfalls are less frequent and snow cover dissipates more rapidly than during the early and mid season periods. Snowfalls that occur in the late season months (September – November) result in snow cover at higher altitudes (>3000m a.s.l), affecting fewer villages than early or mid season events. Further, high-lying roads in the Maluti Range, Central Range, Thaba Putsoa Range, near the escarpment and in the southern Drakensberg highlands are less likely to be snowbound for prolonged periods due to late season snow cover. Therefore, villages are not particularly susceptible to negative impacts associated with prolonged snow cover. However, the spatial nature of late season vulnerability is presented for comparison with early and mid season vulnerability rankings (Figure 5.50). After late season snowfalls, 1843 villages (91.4%) have vulnerability rankings of 1 – 5 (Table 5.20), which is evident in the spatial comparison of late season vulnerability rankings (Figure 5.50). A total of 128 villages (6.3%) have vulnerability rankings of 6 – 10 during the late season period. However, during the late season period no villages have vulnerability rankings greater than 9.

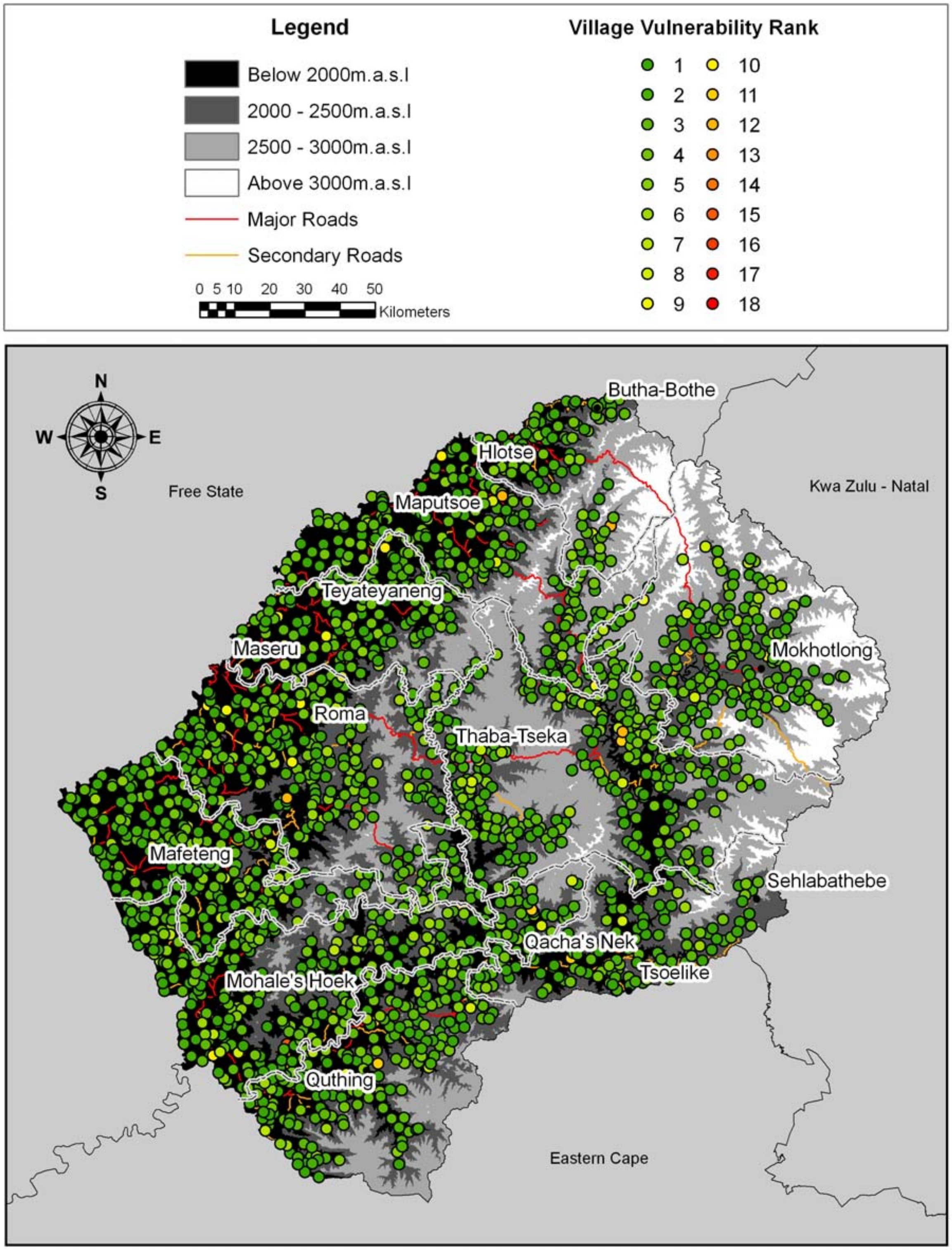

Figure 5.48: Vulnerability of villages to prolonged snow cover in Lesotho during the early season period (April – June).

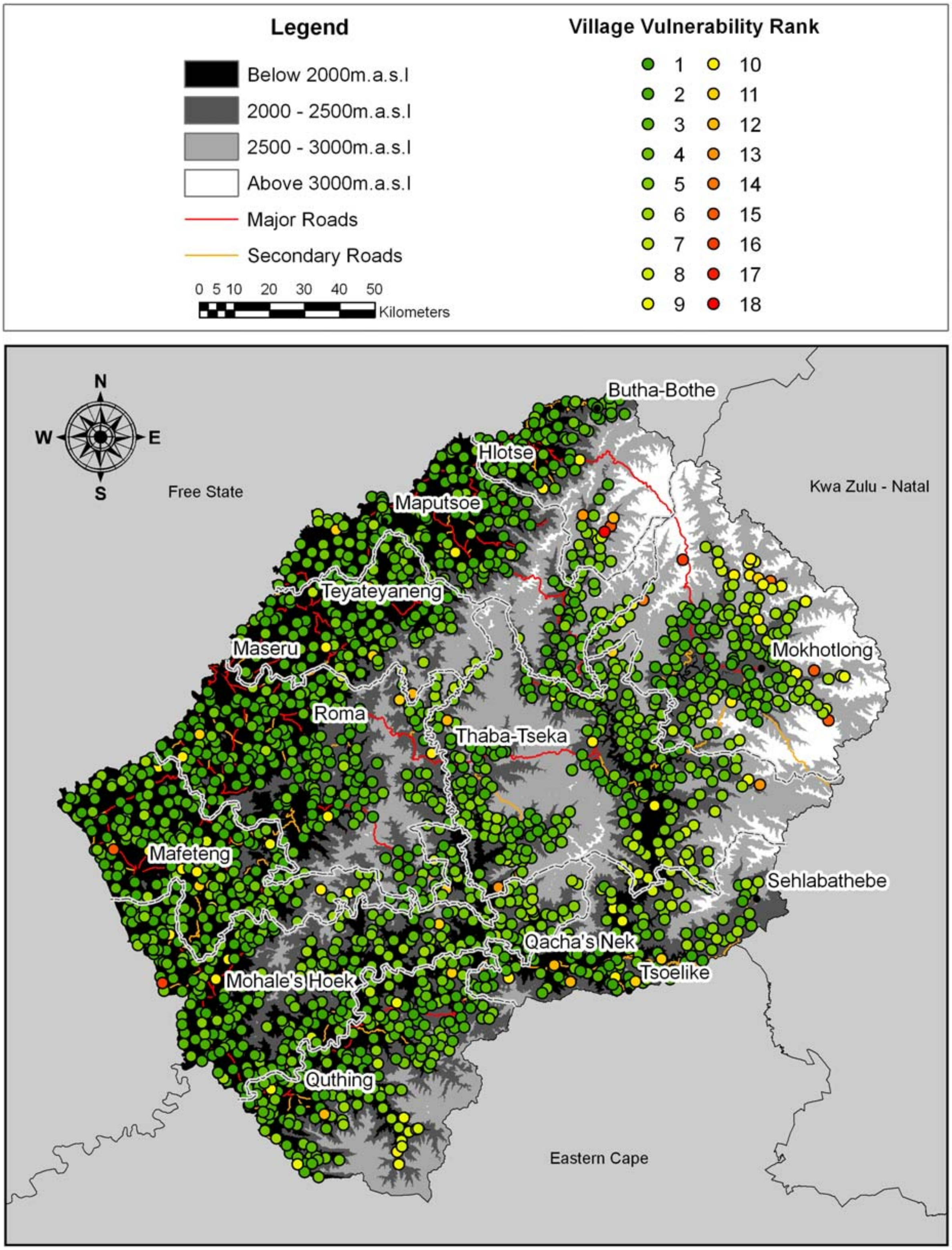

Figure 5.49: Vulnerability of villages to prolonged snow cover in Lesotho during the mid season period (July – August).

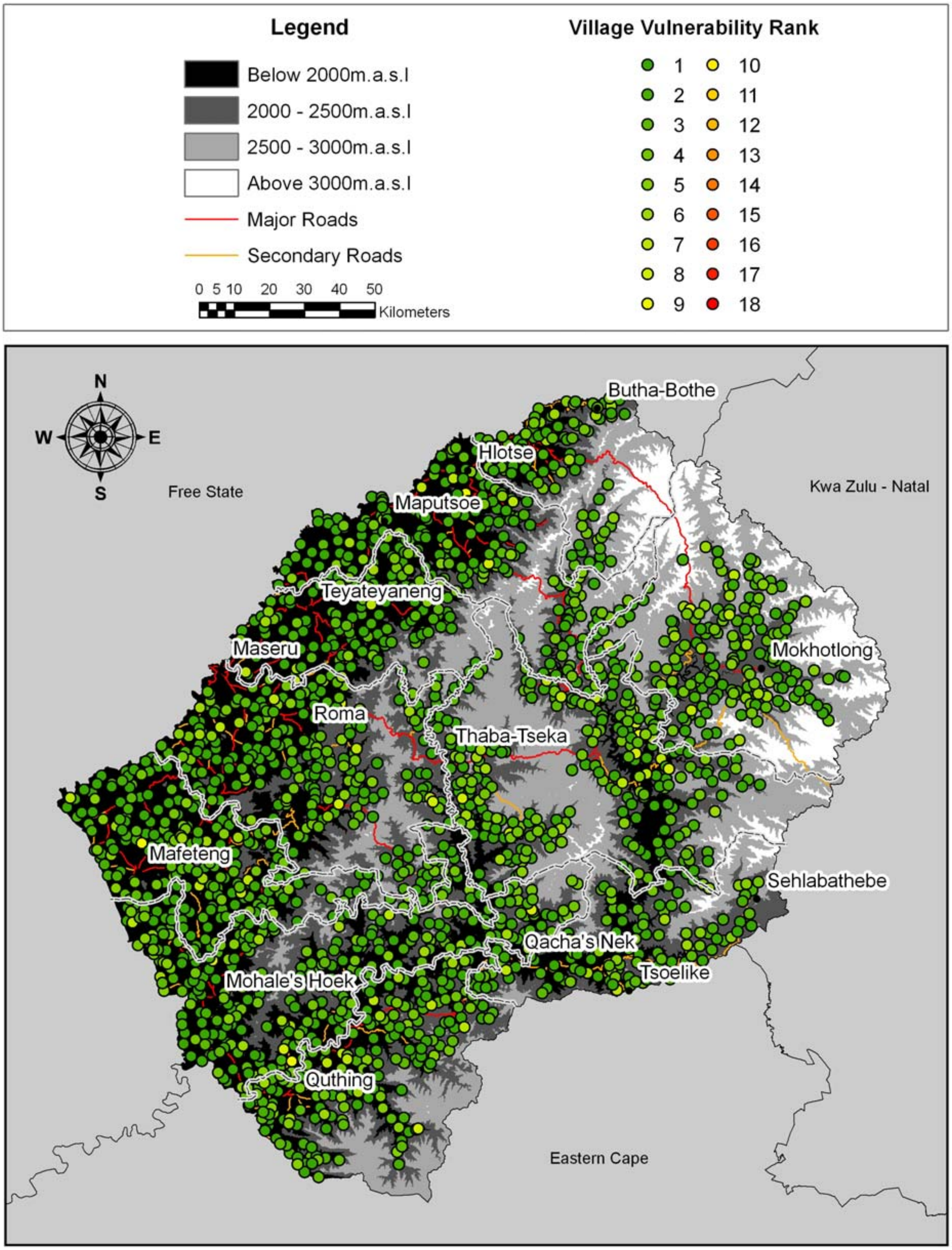

Figure 5.50: Vulnerability of villages to prolonged snow cover in Lesotho during the late season period (September – November).

6. DISCUSSION AND CONCLUSION

6.1 Introduction

Satellite-derived imagery represents one of the most efficient and accurate methods of recording snow cover over wide areas (Gao and Liu, 2001). Previously, remote sensing of snow in Lesotho and the High Drakensberg has been undertaken at various spatial and temporal scales, yet this remains an emerging field due to limited meteorological records (Nel, 2008; Nel and Sumner, 2008) and the cost of high-resolution remote sensing data (Mulder and Grab, 2002; 2009). Snow cover data derived from satellite imagery has recently been compared with the distribution of cold region landforms in the Drakensberg (Grab *et al.,* 2009), yet little is known about the spatial and temporal vulnerability of individual villages in Lesotho to negative impacts associated with prolonged snow cover, despite reports of severe snowfalls frequently resulting in both human and livestock fatalities (Grab and Nash, 2010). Further, there exists no precedent for satellite-based mapping of snow cover in Lesotho at a countrywide scale. Therefore, the analysis of seasonal snow cover distribution and duration presented in this study will contribute to the understanding of snow cover dynamics in the country, whilst providing an indication of the vulnerability of individual human settlements to prolonged snow cover in Lesotho. Remote sensing data is increasingly used for mitigation and mapping of natural hazards, and has been established as a valuable tool for assessing vulnerability (Joyce *et al.,* 2009). Due to the extensive area represented by Lesotho, satellite images were the most practical, affordable and readily available source of snow cover data. GIS software was used to process and manipulate the high number of satellite images used in this analysis, and was also relied upon to classify villages according to their proximity to roads and their location in relation to long-lasting snow cover.

6.2 Analysis of satellite imagery

The MODIS Aqua and Terra satellite images used in this study were selected based on the high spectral resolution, wide spatial coverage and accessibility of MODIS data. The Aqua and Terra satellites have a repeat overpass of one day, thereby providing images every 24 hours recorded in 36 distinct spectral bands with spatial resolution of 250m, 500m and 1km (Hall *et al.,* 1995). The low spatial resolution of MODIS images (250m) is balanced by its high temporal and spectral resolution, which is necessary for mapping snow cover at a countrywide scale. MODIS satellite images have been established as valuable inputs for snow cover mapping (Wang *et al.,* 2006; Hall and Riggs, 2007), especially through the use of band-ratioing techniques such as NDSI (Riggs *et al.,* 2006) and SNOMAP (Hall *et al.,* 1995). Although Landsat imagery has higher spatial resolution (30m pixel size), it only has seven spectral bands, and a repeat overpass of 16 days (Dozier, 1989). The resolution of SPOT imagery (10m and 20m pixel size) is also higher than MODIS, but has poorer spectral and temporal coverage than either Landsat or MODIS (Gao and Liu, 2001). Therefore, snow cover persisting for shorter periods may be missed entirely by Landsat or SPOT sensors.

MODIS Rapid Response imagery has diverse applications in land cover mapping as a result of its near-real time acquisition and is increasingly used in the analysis of seasonal snow cover trends (Haq, 2008; Joyce *et al.,* 2009). A total of 189 processed, rectified MODIS images from 2003 – 2010 were used for snow mapping purposes in this study. However, the record of total monthly and annual snowfalls derived from MODIS imagery used in this study is not comprehensive. Due to the 250m spatial resolution of the MODIS instrument, localized snow cover areas smaller than 250m may be recorded as snow-free, especially if the snow cover area represents a low percentage of the pixel area. Snow cover from smaller, brief snowfall events may have melted completely within 24 hours, leaving no record on the MODIS images.

To ensure accurate detection of snow cover, MODIS images are required to be mostly cloud free (Hall *et al.,* 1995). This constrained the number of suitable images, as the entire extent of Lesotho had to be free from cloud, smoke or haze coverage for an image to be declared suitable. In a few instances, widespread frontal systems resulted in complete obscuration of Lesotho by clouds for several days. Such MODIS images were excluded from analysis, as the dense clouds prevented any snow cover from being recorded. However, snow can be distinguished from cumulus cloud through the application of SNOMAP and NDSI band-ratio techniques, thereby allowing partially cloud-covered images to be included in the analysis of snow cover duration and distribution (Hall and Riggs, 2007). Whilst SNOMAP and NDSI thresholds cannot accurately distinguish snow cover from cirrus clouds (Hall and Riggs, 2007), the presence of cloud is easily established by visual means on MODIS images in a 7-2-1-band composite. Even if a single cloud-covered MODIS image was excluded from a series of consecutive images, a loss of only 24 hours of snow cover data would result.

Topographic elements were derived from a 50m DEM of Lesotho, facilitating the analysis of snowmelt dynamics in relation to altitude and aspect (Cline *et al.,* 1998). The DEM was resampled to match the spatial resolution of MODIS and SPOT images. For the purposes of analyzing seasonal trends in daily rates of snowmelt at various topographic settings, daily satellite imagery is a necessity and MODIS data is therefore a reliable source of snow cover data. A single MODIS image provides coverage of the entire Lesotho region, and therefore eliminates the need for 'stitching' or mosaics (Hall *et al.,* 2002). All MODIS images shared the same spatial extent, which facilitated efficient batch processing of NDSI and SNOMAP algorithms using Idrisi GIS software. The high temporal resolution of MODIS images was an ideal source of data for establishing seasonal trends in the duration and distribution of snow cover in Lesotho. However, with a spatial resolution of 250m, MODIS imagery is suited to land cover mapping over large areas (Hall *et al.,* 2001). For localized snow mapping, the higher resolution of Landsat and SPOT sensors is more suitable. However, The costs of obtaining the equivalent Landsat or SPOT images would be prohibitive. Although MODIS imagery has a relatively coarse spatial resolution of 250m, it is an immensely useful data source because it is freely available on the Internet from the MODIS Rapid Response portal.

The set of 11 SPOT panchromatic images included in this study were used to examine high-resolution snowmelt dynamics in two study regions, in northeastern and southwestern Lesotho. Whilst the 10m spatial resolution enables high resolution snow mapping, the temporal and spectral resolution of SPOT images has limited potential for daily snow mapping over wide areas (Joyce *et al.,* 2009). The SPOT satellite orbits 11 times in 26 days, leaving an interval of several days between satellite overpasses. Further, SPOT images cover a relatively limited area, with a swath of 60 – 80km (Begni *et al.,* 1987). SNOMAP and NDSI algorithms cannot be applied to the SPOT panchromatic images used in this study. As a result, a series of unsupervised classification techniques were applied to the SPOT images with the aid of a GIS. By means of visual comparison, a cluster of 20 automatically grouped pixel values exhibited the most accurate classification of snow-free and snow covered pixels. Despite the limited satellite swath and long intervals between overpasses, the SPOT images used in this study are used to compare snowmelt rates at different settings with the countrywide snowmelt dynamics derived from MODIS imagery.

Given the uneven topography and inaccessibility of the Lesotho highlands and the Drakensberg escarpment, obtaining accurate records of snowfalls remains a challenge (Mulder, 2007; Grab *et al.,* 2009), although continued satellite-based snow cover mapping will enhance the understanding of snow distribution, snowmelt timing and the effects of climate change in this region. Therefore, a range of ground-based measurements, meteorological observations and remote sensing data is required to supplement remote sensing data for constructing a comprehensive record of snowfall events and snowmelt dynamics in Lesotho.

6.3 Village database and additional spatial data

A comprehensive database of 2016 villages in Lesotho was obtained from Dr. Moeti at the National University of Lesotho. The database exists in the form of a GIS shapefile consisting of the name, district, and coordinates of villages. Whilst this remains a valuable resource, it is possible that some villages in Lesotho are not represented by this database. Validating the village dataset is beyond the scope or focus of this research and would require a vast number of aerial photographs, and knowledge of the names and locations of each village in Lesotho. Further, future settlements may develop in new locations, or older villages may cease to exist. However, despite the potential shortcomings of the current village database, the value of assessing the vulnerability of each village in the database would undoubtedly increase the resilience of nearby settlements that may not be represented by the digital dataset, through the dissemination of information.

An additional component of vulnerability to the negative impacts of prolonged snow cover is access to roads. A digital vector layer representing major and secondary roads was created by digitizing roads from a scanned topographic map of Lesotho (Lesotho Government, 1994). The topographic map was the most accurate source of spatial information regarding transport networks in Lesotho, as digital transport route information from Internet-based sources is often not classified down to the level of major and secondary roads. Further, whilst new roads constructed in Lesotho since the creation of the digital topographic map may be absent from the digitized vector road layer, well-established major and secondary roads are assumed to remain in use for at least a few decades. For both the village database and digital road dataset, it is emphasized that the continued collection of accurate and current spatial data is a key requirement of vulnerability assessment.

6.4 SPOT snow cover mapping

An analysis of high-resolution SPOT images from a snowfall in July 2000 indicates that similar amounts of snow cover were recorded for the northeastern study region (528.4 km^2) and the southwestern study region (506.8 km^2) (Figure 5.6). However, snow cover in the southwestern study region dissipated after 10 days whilst snow persisted in the northeastern region for 16 days. Therefore, the northeastern study region exhibited a considerably lower mean rate of daily melt compared with the southwestern region. Whilst the southwestern study region is located in the lowlands between Mafeteng and Quthing, the northeastern study region is located in the highlands near Oxbow and the Drakensberg escarpment. The variability of daily snowmelt rates between the northeastern and southwestern study regions indicates that snow cover duration and distribution is significantly affected by topographic controls. However, melt rates and snow cover duration may not be representative of broader seasonal trends due to the low number of SPOT images used in the analysis and the multi-day interval between satellite overpasses.

6.4.1 Temperature

The snowfall recorded by SPOT images occurred on 16 July 2000, and coincided with low mean day-time temperatures of –2°C on average, and low nocturnal temperatures of –5.6°C on average (Figure 5.8). Whilst the SPOT dataset is limited, with several days between satellite images, certain trends between snowmelt, temperature and spatial location may be established. Mean air temperatures in Lesotho decreased considerably on 24 July 2000. Two days before, snow cover in the northeastern study region was melting at a rate of 19.6%/day on average (Figure 5.7), whilst snow cover in the southwestern study region was melting by 18.9% each day on average (Figure 5.8). However, following the low air temperatures recorded on 24 July 2000, the snowmelt rate decreased to 7.1%/day and 15.3%/day on average in the northeastern and southwestern study regions respectively. Further, SPOT data from the northeastern region indicates that on 31 July 2000 a considerable increase in the mean rate of snowmelt to 16%/day on average coincides with increasing mean air temperatures on the previous day (30 July 2000) (Figure 5.7). One day later, on 1 August 2000, the mean rate of daily melt increased rapidly to 73.3%/day. The comparison of snowmelt rate derived from SPOT imagery and temperature indicates that decreasing air temperatures are frequently followed by slower rates of snowmelt, whilst increasing air temperatures are associated with increasingly rapid snowmelt rates. However, there exists a delay of 2 – 3 days between air temperature changes and the response of snowmelt rates in both the northeastern and southwestern study regions. There exists no significant statistical relationship between the mean rate of daily snowmelt and temperatures (Table 5.1); however, the small sample size of the SPOT image record may responsible. The northeastern study region exhibited a higher mean rate of daily melt (23.18%/day) than the southwestern study region (11.18%/day), indicating that the rate of snow dissipation is influenced by latitude and topographic setting. The relationships indicated between snow cover depletion and mean air temperatures are similar to those observed in the Himalayas, where changes in temperature are directly linked with changes in snow covered area (Singh, 2003).

6.4.2 Altitude

Following the July 2000 snowfall, snow cover in the northeastern study region was concentrated above 3000m a.s.l (Figure 5.4), whilst the majority of snow (76 km^2) in the southwestern study region occurred at lower altitudes around 2450m a.s.l (Figure 5.5). Hence, high-resolution analysis of snowmelt rates indicates that snow cover persists for longer in the northeastern highlands than in the southwestern lowlands of Lesotho during the snowfall in July 2000. Snow cover in the northeastern study region exhibited a maximum mean rate of daily melt of 48%/day on average at 3300m a.s.l, compared with the southwestern study region where snow dissipated by an average of 20%/day at all altitudes below 3000m a.s.l (Figure 5.9). The southwestern study region exhibits a similar melt rate following the August 1992 snowfall, where snow cover melted by 20%/day on average below 3000m a.s.l. However, the northeastern study region exhibits the highest rate of melt at higher altitudes, because the majority of snow cover from the initial snowfall occurred above 3000m a.s.l. Due to the predominantly north-south orientation of the Maluti Range and northern highlands, east- and west-facing slopes dominate the terrain. Conversely, the southwestern lowlands are predominantly east-west aligned and the topography is dominated by north- and south-facing slopes. However, as the northeastern study region experiences more extensive snowfalls and has fewer north-facing slopes than the southwestern study region, snow cover dissipates at a slower rate in the northeastern highlands than in the southwestern study region. Whilst incoming solar radiation has a considerable influence on the rate of snow dissipation (DeBeer and Pomeroy, 2009), the level of insolation at specific topographic settings in Lesotho has not been explored in this study and requires further analysis.

6.4.3 Aspect

Snow cover from the July 2000 snowfall dissipates most rapidly in the northwestern study region, at a maximum rate of 50% each day on average on north-facing slopes (Figure 5.9). This trend may be attributed to severe snow ablation as a result of insolation on northerly aspects (Mulder and Grab, 2002). The mean rate of melt in the southwestern study region for the 1992 snowfall is similar to the snowfall recorded during 2000, at all aspects. However, snow cover melts at a considerably slower rate on north-facing slopes in the southwestern study region (20%/day on average), after the July 2000 snowfall and the August 1992 snowfall. On south-facing slopes, snowmelt remains most rapid in the northeastern study region, whilst snow cover in the southwestern study region share a minimum rate of melt of 4%/day on average. The rate of daily snowmelt rate is highest on average at all altitudes in the southwestern study region after the July 2000 snowfall with a mean of 12.27%/day, whilst the southwestern study region exhibits the lowest mean rate of melt (11.39%/day) on all aspects after the August 1992 snowfall (**Error! Reference source not found.**).

6.5 MODIS snow cover mapping

The MODIS dataset provides an extensive profile of snowfalls occurring during the period 2003 – 2010.However, Landsat browse images were used to obtain the dates of snowfalls prior to 2003 and thus supplement the MODIS snowfall record. Whilst MODIS Rapid Response images are available on a daily basis, Landsat images are separated by a 16-day interval. Therefore, it is likely that the number of snowfalls derived from Landsat browse images is underestimated. Thus, MODIS images provide a far more reliable indication of snowfall frequency in Lesotho. Due to these accuracy concerns, MODIS and Landsat estimates of snowfall frequency are compared both separately and individually. Topographic controls and the influence of temperature on snowmelt are derived exclusively from MODIS Rapid Response 250m-resolution images.

6.5.1 Snowfall frequency

Snowfall frequency calculations from MODIS and Landsat datasets indicate significant inter-annual variability (Figure 5.14). The record of MODIS images for the 8-year period from 2003 – 2010 represents a mean of 5.38 snowfalls per annum (Table 5.4). However, the Landsat record for a 14-year period prior to 2003 has a mean of 2.64 snowfalls per annum. It is evident that MODIS images are more representative of snowfalls than Landsat images (Figure 5.14), although both datasets support the premise that between 1 and 8 snowfalls occur on the Drakensberg escarpment each year on average (Tyson *et al.,* 1976). Based on the MODIS record, the mid season period (July – August) has a mean maximum of 2.38, with an mean maximum of 2.1 during early season months (April – June) and 0.88 during the late season period (September – November) (Figure 5.16). However, based on the Landsat record, the mid season period represents the highest mean maximum number of snowfalls per annum (1.21), as well as the highest mean minimum number of snowfalls per annum (0.36) (Figure 5.15). Despite the discrepancies in the number of mean seasonal snowfalls, both datasets indicate that the majority of snowfalls occur during the mid season months of July and August. This trend is similar to monthly snowfall frequency calculations for the Drakensberg escarpment, which indicate that most winter snowfalls occur between June and August (Mulder, 2007; Mulder and Grab, 2009).

Based on the Landsat record, 2002 yielded 8 snowfalls, the highest number of annual snowfalls recorded during the 1989 – 2002 period (Figure 5.14). In the same year (2002) an average of 1 snowfall occurred each month between April and November. However, most years experience less than 3 snowfalls, with 1 snowfall recorded each year during 1991, 1992, 1993, 1998, 1999 and 2000. Conversely, more than 3 annual snowfalls are recorded for most years between 2003 and 2010 by MODIS images. A total of 8 annual snowfalls were recorded for 2007 and 2008, whilst 7 annual snowfalls were recorded during 2004 and 2010. However, further statistical analysis of monthly and annual snowfall frequency in Lesotho will require a comprehensive dataset of daily satellite images from several decades.

6.5.2 Snowfall extent and duration

The amount of snowfall in Lesotho recorded by the MODIS satellites exhibits considerable annual and seasonal variability for the period 2003 – 2010. The largest snowfall exhibited a spatial extent of 15564.2 km^2 and occurred during August 2006 (Table 5.7). A snowfall occurring in September 2004 produced a snow-covered area of 9828.2 km^2. Several other snowfalls that resulted in widespread snow cover were recorded in June 2009 (9746.14 km^2), August 2004 (8340.4 km^2) and June 2008 (7454.98 km^2). The lowest mean snowfall extent within a given year (355.26 km^2) was recorded in 2005, when three snowfalls were captured. The single largest snowfall was recorded in August 2006 with an extent of 15564.20 km^2, whilst the smallest snowfall extent (82.91 km^2) was recorded in June 2004. The year 2004 had the highest cumulative extent of snowfall (25788.95 km^2) from 7 snowfalls, whilst 2005 had the lowest cumulative snowfall extent (1065.78 km^2) from 3 snowfalls (Table 5.7).

An analysis of mean duration of snow derived from MODIS images for the period 2003 – 2010 indicates that snow cover persists for longer during the mid season months of July and August (Figure 5.18). The mean duration of snow cover following July snowfalls is 11 days, whilst snow cover persists for 9.8 days on average after June snowfalls (Table 5.8). Snow cover lasts for 9.7 days on average in August, and persists for 7.4 days on average during May. Snow cover lasts for an average of 1 day in October, and for only half a day on average during November. This indicates that snow cover persists for longer on average during the mid season period (July and August) than during the early season period (April – June) where snow persists for below 9 days on average. However, snow cover melts most rapidly after late season snowfalls (September – November), where most snow cover is expected to melt after just 5 days on average. Therefore, human and livestock vulnerability to negative impacts associated with prolonged snow cover is highest during the mid season period where snow cover persists longest.

6.5.3 Temperature

An analysis of the relationships between temperature, snow cover area and mean daily melt rates for 16 snowfalls indicates distinct relationships between snow dissipation and mean air temperatures. Firstly, the onset of early and mid season snowfalls is frequently associated with relatively low mean day-time and nocturnal air temperatures. Snowfall on 14 July 2004 was associated with a mean day-time temperature of –4.5ºC and mean nocturnal temperature of –7.5ºC (Figure 5.21). Shortly thereafter, the snowfall on 29 July 2004 was associated with low mean daily and nocturnal temperatures of –4.6ºC and –7.6ºC respectively (Figure 5.22). An early season snowfall occurred on 25 May 2006 and coincided with low mean daily and nocturnal temperatures of –4.1ºC and –6.4ºC respectively (Figure 5.23). This indicates that whilst relatively low air temperatures frequently accompany snowfalls, the duration of snow cover is determined by the timing of the snowfall during the early, mid or late season period.

Secondly, trends appear in the comparison of MODIS-derived snowmelt rates and mean air temperatures that mirror certain aspects of the SPOT-derived melt rates in section 6.4.1. It appears that decreasing air temperatures are frequently followed by considerably slower rates of snowmelt, whilst increasing air temperatures are associated with increasingly rapid snowmelt rates. Similarly, there exists a delay of 1 – 2 days between air temperature changes and the response of snowmelt rates. This effect is most evident during the snowfall on 25 May 2006, where increases in mean daily temperature coincide with considerable increases in mean daily snowmelt rates on 5 distinct occasions (Figure 5.23). Further, temperature decreases coincide with considerably lower rates of snowmelt on 4 occasions after the 25 May 2006 snowfall. The relationship between air temperature and melt rate is evident after the snowfall on 14 July 2004, where on 2 occasions, peaks representing increased mean air temperatures are followed by increased rates of daily snowmelt 2 days later (Figure 5.21).

The relationship between temperature and melt rate appears after the majority of snowfalls recorded by MODIS, in varying degrees. A significant statistical relationship between mean day-time temperature and the mean rate of snow dissipation was identified for a single snowfall event that occurred on 16 July 2009 ($P = 0.01$) (Table 5.9). For 1 – 5 days after early season snowfalls, a positive relationship exists between mean day-time temperatures and mean daily snowmelt rates, although the low correlation coefficient ($r^2 = 0.0065$) indicates the relationship is not statistically significant (Figure 5.27). For 6 – 10 days after early season snowfalls, the positive relationship is stronger ($r^2 = 0.1052$) than for 1 – 5 days after the snowfall, yet the relationship is also not statistically significant. For the 6 – 10 day interval, increasing mean day-time temperatures are associated with a 9.74% increase in the dissipation of snow cover per ºC rise in temperature, compared to an 8% increase in the dissipation of snow cover per ºC rise in temperature represented by the1 – 5 day interval (Figure 5.27).

However, the relationship between day-time temperatures and snowmelt rates is statistically significant for 1 – 5 days ($r^2 = 0.2762$; $P = 0.0058$) and 6 – 10 days ($r^2 = 0.5008$; $P = 0.0496$) after mid season snowfalls (Figure 5.28). This confirms the existence of a trend during the mid season period, where positive or negative variations in mean day-time air temperatures coincide with similar variations in the rate of snowmelt. The relationship is strongest 6 – 10 days after the snowfalls occurring during the mid season period. For the 1 – 5 day interval, there is a –1.5% decrease in the dissipation of snow cover per ºC rise in temperature, compared to a 1% increase in the dissipation of snow cover per ºC rise in temperature represented by the 6 – 10 day interval (Figure 5.28). No significant statistical relationships exist between mean day-time temperatures and rates of snowmelt after late season snowfalls (Figure 5.29). The correlation coefficients for 1 – 5 days ($r^2 = 0.1198$) and 6 – 10 days ($r^2 = 0.07639$) after late season snowfalls were too low to indicate significant relationships. However, the sample sizes were small due to the low number of late season snowfalls, which resulted in such inconclusive statistical findings. For the late season 1 – 5 day interval, there is a 0.2% increase in the dissipation of snow cover per ºC rise in temperature, whilst a 5.7%

increase in the dissipation of snow cover per ºC rise in temperature is represented by the 6 – 10 day interval (Figure 5.29).

The correlation of mean daily snow dissipation rates and mean air temperature from early, mid and late season snowfall events combined yielded robust statistical results (Figure 5.30). Significant statistical relationships exist between melt and temperature for both 1 – 5 days (P = 0.0041, r^2 = 0.1475) and 6 – 10 days (P = 0.0005, r^2 = 0.4276) after snowfalls. For the 1 – 5 day interval, there is a 4.7% increase in the dissipation of snow cover per ºC rise in temperature, compared with a 26.4% increase in the dissipation of snow cover per ºC rise in temperature represented by the 6 – 10 day interval (Figure 5.30). The considerable increase in the rate of dissipation with each ºC rise in temperature between the 1 – 5 and 6 – 10 day intervals emphasizes the dynamic and variable nature of snow longevity and mean air temperatures in Lesotho when compared with Alpine environments such as the Andes (Vuille and Ammann, 1997) and the Australian Alps (Whetton *et al.,* 1996) at similar latitudes in the Southern Hemisphere. In a comparison of snow dissipation and cumulative mean temperature in the Himalayas, Singh (2003) discovered a strong positive correlation (r^2 > 0.98). It was also established that a 2ºC increase in temperature enhanced the melting area of snow by 5.1%. In comparison, the rate of mean daily snowmelt and mean day-time temperatures for Lesotho appear to be correlated to a lesser extent, with the strongest correlation coefficient occurring 6 – 10 days after mid season snowfalls (r^2 = 0.5008) (Figure 5.28). Further, the combined correlation between temperature and snowmelt rates for all seasonal snowfalls in Lesotho indicate a considerable increase in the rate of mean daily melt with a 1ºC rise in temperature for 1 – 5 days (1.2% increase in melt) and 6 – 10 days (8.5% increase in melt) after snowfalls. Further analysis of the correlation between cumulative mean temperature and snow dissipation in Lesotho may yield similar results to the Himalayan study (Singh, 2003), although the latitude and climate of Lesotho lead to a considerably higher rate of snow dissipation with increasing mean day-time air temperatures.

6.5.4 Altitude

For the 1 – 5 day period after early, mid and late season snowfalls, original snow cover melts most rapidly below 1500m a.s.l (Figure 5.31). The original snow cover dissipates at a maximum rate of 100%/day after both early and late season snowfalls, whilst the maximum rate of snowmelt is only 80%/day on average after mid season snowfalls. This indicates that most snow cover resulting from early and late season snowfalls persists for less than 5 days. After early season snowfalls, the minimum rate of original snow cover melt (30%/day on average) occurs at 3350m a.s.l, whilst the minimum late season snowmelt rate is 25%/day on average at the same altitude. Following mid season snowfalls, the minimum rate of melt of the original snow cover is 25%/day at 3300m a.s.l. This indicates that 1 – 5 days after early, mid and late season snowfalls, snow cover persists longest above 3300m a.s.l. However, snow cover will persist longest above this altitude after mid season snowfalls.

Snow cover lasting for 6 – 10 days dissipates considerably slower than snow cover lasting for 1 – 5 days after early, mid and late season snowfalls (Figure 5.32). Original snow cover melts at a maximum rate of 15%/day at 3400m a.s.l after early season snowfalls. However, the maximum melt rate after mid season snowfalls is 9%/day on average at 3450m a.s.l. Following late season snowfalls, original snow cover area decreases by a maximum of 41% each day on average at 3450m a.s.l. The comparison of altitude and snowmelt rate indicates that 6 – 10 days after mid season snowfalls, snow cover melts at the lowest rate and persists for longer at all altitudes than snow cover from early and late season snowfalls.

Based on snow cover data derived from MODIS images, mean daily melt rates were compared to altitude each day up to 9 days after early, mid and late season snowfalls. The mean rates of daily snowmelt exhibit interseasonal relationships, yet variation also exists temporally within each seasonal period. Initially, early season snowmelt rates are relatively high, especially 1 day after the snowfalls when snow cover melts at a maximum mean rate of 88%/day on average at 1750m a.s.l (Figure 5.33). However, the maximum rates of early season snowmelt begin to decline with time after original snowfalls. For example, 2 days after the snowfalls, early season snow cover dissipates at a considerably lower maximum rate of 43%/day on average at 2150m a.s.l (Figure 5.34). Three days after the snowfalls, a maximum mean melt rate of 51%/day on average was recorded at 2150m a.s.l (Figure 5.35). After 4 days, the mean rate of daily snowmelt reaches a maximum of 73%/day on average at 2500m a.s.l (Figure 5.36). By 5 days after early season snowfalls, the maximum mean rate of daily snowmelt reaches 50%/day on average at 1750m a.s.l (Figure 5.37). Six days after the snowfall, the mean daily rate of early season snowmelt is highest (36%/day on average) at 3350m a.s.l (Figure 5.38), and by 7 days the maximum rate of snowmelt is 44%/day on average at 3300m a.s.l (Figure 5.39). However, 8 days after early season snowfalls, the mean rate of snowmelt reaches a maximum of 80%/day at 2450m a.s.l (Figure 5.40), whilst 9 days after the snowfalls the maximum snowmelt rate is 79%/day on average at 2950m a.s.l (Figure 5.41). In summary, the mean rates of snowmelt are highest 1 day after the snowfall than at any other time. Further, these high snowmelt rates are associated with low altitudes (~1750m a.s.l). Therefore, more snow cover persists at high altitudes (>3000m a.s.l) 1 day after the snowfalls. However, 2 – 7 days after early season snowfalls, the maximum mean rates of daily snowmelt are relatively lower than for 1 day after the snowfalls, yet they are associated with higher altitudes (up to 3350m a.s.l). During this period, snow cover at all altitudes dissipates less rapidly than 1 day after the snowfall, with snow cover melting relatively quicker above 3000m a.s.l. Subsequently, the mean rates of daily snowmelt increase considerably 8 – 9 days after early season snowfalls, with snow cover dissipating most rapidly between 2450m a.s.l and 2950m a.s.l. Therefore, snow covered areas persisting for 9 days or longer dissipate at an increasingly rapid rate, at all altitudes above 2000m a.s.l.

Initially, mean daily melt rates after mid season snowfalls are relatively high. One day after the snowfalls, the maximum rate of mean daily melt (94%/day) occurs at an altitude of 1750m a.s.l (Figure 5.33). However, snow cover melts considerably slower 2 days after mid season snowfalls, with a maximum rate of melt (44%/day on average) at 2500m a.s.l (Figure 5.34). The maximum rate of mean daily snowmelt 3 days after mid season snowfalls also remains relatively low, at 42%/day on average at 1950m a.s.l (Figure 5.35). Four days after mid season snowfalls, the maximum rate of daily snowmelt increases to 58%/day on average at an altitude of 2500m a.s.l (Figure 5.36). A maximum snowmelt rate of 40%/day on average is recorded at 2500m a.s.l, 5 days after the snowfalls (Figure 5.37). However, 6 days after the snowfalls, the maximum mean rate of daily melt increases to 53% at 2350m a.s.l (Figure 5.38). A subsequent decrease to 24%/day on average is recorded at 3050m a.s.l, 7 days after mid season snowfalls (Figure 5.39). By 8 days after the snowfalls, the maximum mean rate of snowmelt is 40%/day on average at 3000m a.s.l (Figure 5.40), and decreases to 30%/day at 2450m a.s.l after 9 days (Figure 5.41). In summary, the most rapid mean daily melt rate of mid season snow cover occurs 1 day after the snowfalls, at relatively low altitude (1750m a.s.l). The relationship between altitude and mean daily snowmelt rates is similar for 1 and 5 days after early and mid season snowfalls. However, between 6 and 10 days after the snowfalls, the mid season rate of daily snowmelt falls below the early and late season melt rates. This is an indication of snow persisting for longer at all altitudes during the mid season period. Further, between 4 and 9 days after the snowfalls, mid season snowmelt rates extend to lower altitudes than after early and late season snowfalls. This indicates that mid season snowfalls result in more extensive snow covered areas at lower altitudes than early or late season snowfalls. Finally, in contrast to the early season trend of increasing rates of snowmelt with increasing altitude, mid season snow cover tends to melt consistently at all altitudes, persisting for longer than either early or late season snow cover.

Snow cover melts most rapidly after late season snowfalls, dissipating at a maximum rate of 99%/day at 1750m a.s.l, 1 day after the snowfalls (Figure 5.33). The mean rate of daily snowmelt after 2 days remains relatively high, reaching a maximum of 92%/day on average at 1900m a.s.l (Figure 5.34). Three days after late season snowfalls, snow cover melts at a maximum rate of 90%/day at 2600m a.s.l (Figure 5.35), increasing to 100%/day on average between 1850m a.s.l and 2100m a.s.l, four days after the snowfalls (Figure 5.36). The mean rate of daily snowmelt remains high 5 days after late season snowfalls, dissipating at a maximum rate of 92% each day on average at 2450m a.s.l

(Figure 5.37). However, 6 days after the snowfalls, the mean daily snowmelt rate decreases to 67%/day on average at 2150m a.s.l (Figure 5.38), and is marginally higher 7 days after the snowfalls with a maximum snowmelt rate of 76%/day at 3200m a.s.l (Figure 5.39). For 8 and 9 days after late season snowfalls, the maximum mean rate of daily snowmelt is 100%/day on average at 3100m a.s.l (Figure 5.40 and Figure 5.41). Snow cover melts most rapidly during the late season period, and snow cover at higher altitudes (>2000m a.s.l) melts increasingly rapidly with time following late season snowfalls. Snow cover frequently persists for only a few days after late season snowfalls, due to the considerably high mean rates of daily snowmelt.

Snow cover from original snowfalls dissipates at the least rapid mean rate 1 – 5 days after mid season snowfalls (29.67%/day), compared with early season (44.81%/day) and late season snowfalls (34.82%/day) (Table 5.10). However, 6 – 10 days after snowfalls, original snow cover dissipates at the least rapid mean rate after late season snowfalls (3.10%/day) followed by mid (3.99%/day) and early season snowfalls (6.22%/day). Snow cover from the previous day dissipates at the least rapid mean rate 1 – 5 days after mid season snowfalls (32.01%/day), compared with early season (37.65%/day) and late season snowfalls (46.18%/day) (Table 5.11). From 6 – 10 days after snowfalls, remaining snow cover also dissipates at the least rapid mean rate after mid season snowfalls (15.14%/day) followed by early (33.21%/day) and late season snowfalls (38.41%/day). These statistics emphasize the distinct seasonal variations in the rate of snow dissipation in Lesotho, whereby snow cover persists longest during the mid season period, and dissipation is most rapid during the late season period. Further, the mean rate of snow dissipation decreases for snow that persists for 6 – 10 days, however the most considerable decrease occurs after mid season snowfalls (Table 5.11). This is potentially a result of lower mean air temperatures in the winter months of July and August, as well as the effect of topographic shading and variations in the angle of incidence of solar radiation.

6.5.5 Aspect

An analysis of aspect and mean rates of snowmelt indicate that 1 day after early, mid and late season snowfalls, snow cover melts at a rate of 50%/day on average on north-facing slopes. Late season snow cover dissipates at the slowest rate (10%/day on average) on south-facing slopes (Figure 5.33). It is argued that snow on south-facing slopes persists longer than on north-facing slopes due to lower insolation levels (Mulder and Grab, 2002). However, between 2 and 9 days after the snowfalls, late season snowfalls exhibit the most rapid mean rate of snowmelt on all aspects (Figure 5.34). Between 1 and 6 days after the snowfalls, early season snow cover dissipates at the slowest rate on all aspects. However, beyond 7 days after the snowfalls, mid season snow cover persists for longest on all aspects (Figure 5.39). For all seasons, the highest mean daily snowmelt rate occurs on north-facing slopes, and the lowest mean rate occurs on south-facing slopes. During all seasons, the mean rate of snow dissipation is more rapid on east-facing slopes than on west-facing slopes. In summary, snow cover on south-facing slopes will persist longest during the early season period initially, but with increasing time after snowfalls, mid season snowfalls will persist longer on south-facing slopes. Late season snow cover will dissipate most rapidly at all slope aspects.

6.6 Implications for vulnerability

Remotely sensed imagery highlights spatial changes over time, providing information on the changing size, extent and influence of hazardous events. Therefore, satellite images are commonly used for mapping the extent of geophysical threats and delineating areas that may be affected by such events (Espizua and Bengochea, 2002). However, many environmental hazards are unpredictable in terms of their spatial impact, speed or duration (Cova and Church, 1997). The utility of GIS for hazard mapping and disaster management is increasing, as it enables users to compare data statistically and spatially, and visualize the resulting products and images (Karimi and Houston, 1997; Zerger and Smith, 2003). Satellite images have been integrated with spatial data in a GIS, to investigate the vulnerability of villages in Lesotho to negative impacts associated with long lasting snow cover. Vulnerability to prolonged snow cover is expressed as a function of the duration of snow cover experienced by each village and the proximity and accessibility of roads.

6.6.1 Duration of snow cover

Over 97% of villages in all districts experienced snow for the period 2003 – 2010 (Table 5.20), indicating that widespread snow cover is a relatively frequent occurrence, especially above 2500m a.s.l in the eastern half of Lesotho. Low-lying areas such as the western lowlands and Senqu River Valley remain relatively free from snow cover throughout the winter season. Snow cover maps of mean and maximum duration of snow cover indicate that long-lasting snow cover (> 15 consecutive days) occurs only during the mid season period and is confined to high-lying areas in certain ranges > 2500m a.s.l (Figure 5.43). Further, the escarpment acts as an orographic barrier to cold fronts passing across southern Africa, resulting in the rapid reduction of snow cover west of the escarpment in Lesotho (Mulder and Grab, 2002; Mulder, 2007). This effect is clear after mid season snowfalls, where snow cover with the highest mean duration (Figure 5.43) and maximum duration (Figure 5.46) occurs in the southern Drakensberg highlands in Quthing. Whilst persistent snow cover (> 10 consecutive days) is evident in localized areas of the Thaba Putsoa Range, Central Range, Maluti Range and the escarpment above 2500m a.s.l, the orographic barrier of the escarpment prevents cold fronts approaching from the southwest from penetrating northwards into Lesotho (Mulder and Grab, 2002; Mulder, 2007). The majority of snow cover is short-lived with a mean duration of less than 5 days per annum (Figure 5.42). Limited snow cover with a mean duration of 6 – 10 days per annum occurs in the Maluti Range and the southern Drakensberg highlands near Quthing, and in localized regions on the Thaba Putsoa Range and eastern escarpment. Early season snow cover with the longest mean duration per annum (11 – 15 days) occurs in isolated patches in the southern Drakensberg highlands (Figure 5.42). However, the maximum duration of snow cover is six consecutive days after early season snowfalls (Figure 5.45). Isolated and longer-lasting snow patches exist on the escarpment between

Mokhotlong and Sehlabathebe, on the Thaba Putsoa Range near Mohale's Hoek, on the Maluti Range, on the Central Range near Qacha's Nek, and in the southern Drakensberg highlands near Quthing and Mount Moorosi, with a maximum of 4 – 6 consecutive days of snow cover during the period 2003 – 2010 (Figure 5.45).

Mid season snow cover is generally more extensive and prolonged than during the early season period (Figure 5.43). Snow cover persisting for 1 – 5 days on average per annum is widespread on all mountain ranges in Lesotho, especially on the escarpment and the Maluti Range. Longer-lasting snow cover (6 – 10 days mean duration per annum) occurs extensively on the escarpment near Mokhotlong and Sehlabathebe, as well as in the southern Drakensberg highlands near Quthing. During the mid season period, snow cover with the greatest mean duration per annum (21 – 25 days) occurs in a relatively minor extent on the southern Drakensberg highlands in Quthing district (Figure 5.43). Following mid season snowfalls, most snow covered areas persisting for a maximum of 1 – 3 consecutive days during the period 2003 – 2010 (Figure 5.46). Mid season snow cover persisting for a maximum of 4 – 6 consecutive days is conspicuous on the escarpment between Mokhotlong and Sehlabathebe, including the ridges of the Maluti Range, Thaba Putsoa Range and the Central Range. Snow cover lasting for a maximum of 10 – 12 consecutive days during the period 2003 – 2010 occurs along the escarpment, in the Maluti Range, Thaba Putsoa Range and the Central Range, as well as the southern Drakensberg highlands near Quthing. Longest lasting mid season snow cover (maximum of 13 – 15 consecutive days of snow cover) is prevalent mainly in Quthing on the southern Drakensberg highlands, but also occurs in fragmented patches over the Thaba Putsoa Range, the Central Range, and the Maluti Range (Figure 5.46). However, minor patches of isolated snow cover persisting for a maximum of 13 – 15 days occur on the escarpment between Mokhotlong and Sehlabathebe.

For late season snowfalls occurring during the period 2003 – 2010, the maximum mean duration of snow cover per annum is 1 – 5 days (Figure 5.44). Snow cover is considerably less widespread and less prolonged than after early or mid season snowfalls, and the western half of Lesotho is free from snow. Late season snow cover is generally absent from the Maluti Range and the Thaba Putsoa Range, however, limited snow patches occur on the Central Range near Qacha's Nek. On average, the majority of late season snow cover is concentrated on the escarpment between Mokhotlong and Sehlabathebe and persists for 1 – 5 days on average per annum (Figure 5.44). After late season snowfalls, snow cover persists for a maximum of 1 – 3 consecutive days for the period 2003 – 2010 (Figure 5.47). The maximum extent of snow cover is less widespread than during the early and mid season periods. The considerably shorter maximum duration of snow cover during the late season period is a result of increasing mean air temperatures and decreasing frequency of snowfalls associated with the onset of warmer climatic conditions in spring.

6.6.2 Proximity and accessibility of roads

A digital map of major and secondary roads was generated for Lesotho using scanned topographic maps. Whilst this method yielded accurate representation of roads, it has the potential of overlooking smaller roads and tracks that may not appear on topographic maps. Therefore, aerial photographs or multiple high-resolution satellite images would yield significantly more accurate spatial information on the location of all transport routes in Lesotho. However, this would potentially prove to be time-consuming, and satellite-derived imagery may be costly. The location of villages to major and secondary roads is considered a key indicator of vulnerability; however, the accessibility of such roads is critical. Spatial analysis reveals that a total of 1009 villages in Lesotho are located within 4.25km of a major road, and 874 villages are located within 4.25km of a secondary road (Table 5.15). The number of settlements located further from roads decreases considerably with increasing distance from major and secondary roads. No villages are located further than 29.75km from the nearest major or secondary road (Table 5.15). The majority of villages (2008) are situated nearest to roads that experience a short duration of snow cover (1 day per annum) (Table 5.16). It has been established that few major and secondary roads traverse high-lying terrain and mountain ranges in Lesotho (>2500m a.s.l). Further, prolonged snow cover occurs predominantly above such altitudes; therefore most major and secondary roads are less likely to be snowbound during the year. However, the maximum duration of snow cover on major and secondary roads indicates that coverage by snow for ≥4 days remains a possibility (Table 5.17).

6.6.3 Overall vulnerability

For villages in Lesotho, overall vulnerability has been calculated as a factor of snow cover duration during the winter season, and proximity and accessibility of roads. Individual vulnerability rankings are presented in Appendix 1. Whilst these elements represent physical and spatial vulnerability, the overall vulnerability expressed in this thesis is not indicative of socioeconomic vulnerability. Further, the record of MODIS imagery remains limited temporally, therefore long-term relationships between snowfall frequency, snow cover duration and village vulnerability cannot be established. However, the 8-year period represented by daily MODIS images has yielded valuable results, and the vulnerability rankings derived from these data provide a baseline framework on which further research can be established. Villages with the highest vulnerably to snow cover during the early season period (April – June) are Anone (Quthing), Aupolasi (Mokhotlong), Liteleng (Butha-Buthe), Setleketseng (Butha-Buthe), Thaba - Khubelu (Mokhotlong), Thopo (Butha-Buthe), Bolula (Mokhotlong), Ha Makepe (Mokhotlong), Ha Matsumunyane (Leribe), and Ha Ranqhangoana (Mokhotlong) (Table 5.21). For the mid season period (July and August), villages with highest vulnerability are Thoteng (Butha-Buthe), Letseng-la-Terae (Mokhotlong), Mabalane (Butha-Buthe), Liteleng (Butha-Buthe), Ha Rannini (Mokhotlong), Letseng (Mohale's Hoek), Mohlanpeng (Butha-Buthe), Bahaoleng (Thaba-Tseka), Ha Kanono (Mokhotlong), and Liqalaneng (Butha-Buthe) (Table 5.22). The most vulnerable villages to late season snow cover are Liphaleng (Leribe), Lithipeng (Mohale's Hoek), Khotojieng (Thaba-Tseka), Likonyeleng (Qacha's Nek), Ha Mashenephe (Quthing), Kopanong (Berea), Tsieng (Maseru), Matsabeng (Mokhotlong), Lehlakaneng (Butha-Buthe) and Lumang (Thaba-Tseka) (Table 5.23). The number of villages vulnerable to prolonged snow cover in Lesotho is relatively low, and more villages are vulnerable to prolonged snow cover during the mid season period (1987) than during the early season (1974) and late season periods (1971) (Table 5.20). Villages near the escarpment and near the interior mountain ranges are more vulnerable to long lasting snow cover than villages in the western Lowlands and Senqu River Valley. However, out of the maximum vulnerability ranking (40), the highest ranked village is Thoteng (18) in Butha-Buthe, during the mid season period. Based on the ranking system applied throughout this study, it is evident that vulnerability is generally low to negative impacts associated with long lasting snow. Whilst vulnerability to prolonged snow cover is apparently low, it has been established that human and livestock deaths occur frequently (Grab and Nash, 2009). Therefore, the vulnerability rankings presented in this dissertation may at least direct evacuation or relief efforts on a small group of known settlements. The level of assistance for vulnerable villages can be matched according to individual vulnerability during the early, mid and late season periods. There is strong potential for future research to confirm the village vulnerability rankings and location through extensive ground-truthing. This undertaking will not only further the understanding of vulnerability to negative impacts associated with prolonged snow cover, but will also increase the digital spatial database of villages in Lesotho that may not be represented in the database used in this thesis. Further, the basic vulnerability ranking system used in this study has the potential to be strengthened in future by including indicators of socioeconomic and biophysical vulnerability.

6.7 Potential for further research

Whilst interactions between snow extent, duration, topographic controls and vulnerability were explored on a countrywide scale in this dissertation, it is widely acknowledged that there is a considerable lack of meteorological, biophysical and socioeconomic data for Lesotho (Mulder and Grab, 2002; Nel and Sumner, 2005; Ziervogel *et al.,* 2006; Mulder, 2007, Nel, 2008; Nel and Sumner, 2008; Grab *et al.,* 2009; Mulder and Grab, 2009; Nel *et al.,* 2010; Obioha, 2010). Given recent developments in remote sensing and the growth of the Internet as a source of remote sensing data, satellite imagery is becoming increasingly accessible at minimal costs. This has significant implications for future snow cover mapping in Lesotho and over the Drakensberg escarpment using multi-temporal satellite images.

Several elements of snow dynamics were analyzed in this dissertation, except for the depth of snow in Lesotho, which has implications for fauna and flora (Van Zinderen Bakker and Werger, 1974; Schmitz and Rooyani, 1987; Evans *et al.,* 1989; Killick, 1990; Mokotjomela, 2007) and possibly human and livestock vulnerability. Given current developments in LiDAR and laser range-finding technology (Zwally *et al.,* 2002; Hood and Hayashi, 2010; Sovilla *et al.,* 2010) and ground-based measurements coupled with GPS technology, there is a strong potential for snow depth mapping in Lesotho.

Countrywide snow cover mapping always requires ground-truthing, to validate the accuracy of snow classification. However, this dissertation made use of a digital village database that also has scope for ground-truthing to confirm the precise location of settlements. Internet-based sources of spatial information such as Google Earth© may also be used to construct an accurate and more comprehensive village dataset.

The vulnerability of livestock is problematic to assess, as the concentration of such animals changes spatially and temporally. However, remote sensing techniques can be used in future to classify grazing/range land in Lesotho, and by analyzing the location of such land spatially in relation to snow cover duration, livestock vulnerability maps can be constructed using GIS. However, the spatial resolution of MODIS 250m imagery is too coarse for localized land cover mapping, therefore satellite-derived images from high-resolution platforms such as Landsat or SPOT must be employed.

6.8 Conclusion

Remote sensing of snow in Lesotho and the High Drakensberg has been undertaken at various spatial and temporal scales, yet this remains an emerging field due to limited meteorological records and the cost of high-resolution remote sensing data (Mulder and

Grab, 2002; 2009; Nel and Sumner, 2008; Nel; 2008; Grab *et al.,* 2009). The use of remote sensing techniques such as NDSI and SNOMAP thresholds and unsupervised classification were applied to MODIS and SPOT data for snow mapping purposes. Snowfall frequency maps for Lesotho were derived from MODIS 250m resolution images for the period 2003 – 2010. Topographic controls of snow cover were analyzed using a DEM in conjunction with MODIS and SPOT satellite images for comparison of seasonal snowmelt rates. Digital village and road data were integrated with snow cover maps in a GIS to investigate the spatial and temporal dimensions of vulnerability in Lesotho. However, any decisions based on the output of a GIS must allow for potential errors in data inputs, and should be confirmed by ground-truthing or by comparison with external datasets (Zerger, 2002).

Given the exposure of snow-related hazards globally (Margreth and Funk, 1999; Gruber and Bartelt, 2007; Pinto *et al.,* 2007; Podolskiy *et al.,* 2010; Prior and Kendon, 2011), little is known about the spatial and temporal vulnerability of individual villages in Lesotho, despite reports of severe snowfalls frequently resulting in both human and livestock fatalities (Grab and Nash, 2010). A total of 2016 villages in Lesotho were individually ranked according to the duration of seasonal snow cover derived from MODIS satellite images. GIS distance operators were used to calculate the proximity to the nearest road for each village; whilst the accessibility of these roads was determined by analyzing the intersection between roads and snow cover duration maps. Ultimately, each village in Lesotho was assigned an overall vulnerability ranking for early, mid and late season snowfalls (Appendix 1). Whilst other factors contributing to human and livestock vulnerability are excluded from this analysis, such data often lack the necessary spatial and temporal resolution to provide meaningful countrywide estimates of vulnerability.

The use of multi-temporal satellite imagery to map the seasonal dynamics of snow cover in Lesotho is unique to this study. Further, this research highlights the importance of Internet-based sources of low-cost digital spatial information such as satellite images, DEMs and topographic data inputs. GIS is an invaluable tool for analyzing such multilayered datasets and constructing hazard maps especially in remote, mountainous regions (Oberoi and Thakur, 2005). By contributing to the limited understanding of seasonal variations in snow cover duration and extent in Lesotho, this dissertation will hopefully provide part of the framework for future research in the region to be undertaken at increasingly high spatial and temporal scales.

The vulnerability assessment presented in this dissrtetaion falls within the aims set out by the International Strategy for Disaster Reduction in Africa; by improving the assessment and identification of hazards, contributing to risk reduction through mitigation, and enhancing the efficiency of emergency response management in Lesotho (ISDR, 2004). Further, the identification of natural hazards and vulnerable communities in Lesotho is essential, given predictions of future global climate change (IPCC, 2007; Obioha, 2010). This dissertation is in accordance with the framework of the Southern Africa Vulnerability Initiative (SAVI), which aims to assess local vulnerability to multiple stressors (O'Brien *et al.,* 2009). The long-term mapping of seasonal snow cover over Lesotho undertaken in this study will contribute to the assessment of communities and regions that may be affected by climate change, which is one of the key requirements of the National Adaptation Programme of Action in Lesotho (NAPA, 2006). The assessment of regional vulnerability in Lesotho on a countrywide scale has implications for food security, through the identification of areas with significant snow cover potential (Mock, 2005). As this dissertation has identified multiple zones that experience variable seasonal vulnerability, the outputs are relevant to the Lesotho Vulnerability Assessment Committee in the context of food security (LVAC, 2004). Identification of seasonal and spatial risk is equally important for livestock and humans, therefore the vulnerability assessment presented in this study is inclusive of livestock animals (Freeman *et al.,* 2003). Ideally, the assessment of seasonal biophysical vulnerability conducted during this study will enhance the management and response to snow-related hazards in all human settlements in Lesotho. However, the need for accurate and comprehensive vulnerability statistics for a range of hazards affecting individual villages in Lesotho is highlighted by the current prevalence of HIV/AIDS in the region (Nyabanyaba, 2008; Piot *et al.,* 2008). There exists a unique opportunity to integrate physical and socioeconomic vulnerability assessments, especially with growing awareness of the linkages between climate variability, food security and livelihoods in Lesotho (Turner, 2003; FIVIMS, 2005; Ziervogel *et al.,* 2006; Nash and Grab, 2010; Obioha, 2010).

7. REFERENCES

Albert, T.H., 2002: Evaluation of remote sensing techniques for ice-area classification applied to the tropical Quelccaya Ice Cap, Peru, *Polar Geography,* 26(3): 210–226.

Alcántara-Ayala, I., 2002: Geomorphology, natural hazards, vulnerability and prevention of natural disasters in developing countries, *Geomorphology*, 47:107–124.

Allen, N.J.R., 1986: Accessibility and altitudinal zonation models of mountains, *Mountain Research and Development*, 6(3): 185–194.

Anderton, S.P., White, S.M., and Alvera, B., 2002: Micro-scale spatial variability and the timing of snow melt runoff in a high mountain catchment, *Journal of Hydrology*, 268: 158–176.

Andrés, N., García-Romero, A., Muñoz, J., and Palacios, D., 2005: Influence of snow distribution in vegetation cover and geomorphologic activity: Manzanares Headvalley, Sierra de Guadarrama, Spain, *Geophysical Research Abstracts*, Vol. 7, 08551, 2005.

Annan, A.P., 2002: GPR – history, trends, and future developments, *Subsurface Sensing Technologies and Applications*, 3: 253–270.

Argawal, N.K., 1989: Terrestrial photogrammetric mapping of the Neh- Nat glacier in Himalaya, India. *ISPRS Journal of Photogrammetry and Remote Sensing*, 44: 245–252.

Baiphethi, M.N., and Jacobs, P.T., 2009: The contribution of subsistence farming to food security in South Africa, *Agrekon*, 48(4): 459–482.

Bajracharya, S.R., and Mool, P.K., 2007: Melting glaciers in the Himalayas, *Mountain Forum Bulletin*, 7(2): 5 – 6.

Basher, R., 2006: Global early warning systems for natural hazards: systematic and people-centred, *Philosophical Transactions of the Royal Society A,* 364: 2167–2182.

Bavay, M., Lehning, M., Jonas, T., and Löwe, H. 2009: Simulations of future snow cover and discharge in Alpine headwater catchments, *Hydrological Processes*, 23: 95–108.

Bebi, P., Kulakowski, D., and Rixen, C., 2009: Snow avalanche disturbances in forest ecosystems—State of research and implications for management, *Forest Ecology and Management*, 257: 1883–1892.

Begni, G., Boissin, B., and Leroy, M., 1987: *Results of SPOT 1 images: Quality Assessment Program*, Centre National d'Etudes Spatlales, Toulouse Cedex, France, 6pp.

Beniston, M., 1997: Variations of snow depth and duration in the Swiss Alps over the last 50 years: links to changes in large-scale climatic forcings, *Climate Change*, 36: 281–300.

Beniston, M., 2003: Climatic change in mountain regions: a review of possible impacts, *Climate Change*, 59:5–31.

Birkman, J., 2007: Risk and vulnerability indicators at different scales: applicability, usefulness and policy implications, *Environmental Hazards*, 7: 20–31.

Bishop, M.P., Shroder, A.F., and Colby, J.D., 2003: Remote sensing and geomorphometry for studying relief production in high mountains, *Geomorphology*, 55: 345–361.

Blesius, L., and Weirich, F., 2005: The use of the Minnaert correction for land-cover classification in mountainous terrain, *International Journal of Remote Sensing*, 26 (17): 3831–3851.

Bloom, D.E., and Sachs, J.D., 1998: *Geography, Demography, and Economic Growth in Africa*, Harvard Institute for International Development, 1–67.

Boelhouwers, J.C., and Meiklejohn, K.I., 2002: Quaternary periglacial and glacial geomorphology of southern Africa: review and synthesis, *South African Journal of Science*, 98:47–55.

Boelhouwers, J., Holness, S., Meiklejohn, I., and Sumner, P., 2002: Observations on a blockstream in the vicinity of Sani Pass, Lesotho Highlands, Southern Africa, *Permafrost and Periglacial Processes*, 13: 251–257.

Bogetic, Z., 2006: *International benchmarking of Lesotho's infrastructure performance*, World Bank Policy Research Working Paper 3825.

Boudhar, A., Hanich, L., Boulet, G., Duchemin, B., Berjamy, B. and Chehbouni, A., 2009: Evaluation of the snowmelt runoff model in the Moroccan High Atlas Mountains using two snow-cover estimates, *Hydrological Sciences*, 54: 1094–1113.

Bouillon, A., Bernard, M., Gigord, P., Orsoni, A., Rudowski, V., and Baudoin, A., 2006: SPOT 5 HRS geometric performances: Using block adjustment as a key issue to improve quality of DEM generation, *ISPRS Journal of Photogrammetry & Remote Sensing*, 60: 134–146.

Bradford, J., Harper, J., and Brown, J., 2009: Complex dielectric permittivity measurements from ground-penetrating radar data to estimate snow liquid water content in the pendular regime, *Water Resources Research*, 45: 1–12.

Braimoh, A.K., and Vlek, P.L.G., 2004: Land-cover dynamics in an urban area of Ghana, *Earth Interactions,* 8: 1–15.

Brander, D., Seidel, K., Zurflüh, M., and Huggel, C., 2000: *Snow cover maps in Alpine regions from remote sensing data*, Proceedings of EARSeL-SIG-Workshop Land Ice and Snow, Dresden/FRG, June 16 – 17, pp 292–296.

Brázdil, B., Pfister, C., Wanner, H., Von Storch, H., and Luterbacher, J., 2005: Historical climatology in Europe – the state of the art, *Climate Change*, 70: 363–430.

Brivio, P.A., Giardino, C., and Zilioli, E., 2001: Validation of satellite data for quality assurance in lake monitoring applications, *The Science of the Total Environment*, 268: 3–18.

Brown, R.D., 2000: Northern hemisphere snow cover variability and change, 1915–97, *Journal of Climate*, 13: 2339–2355.

Brown, A. 2009: *Understanding the Impact of Climate Change on Snowpack Extent Measurement in the Columbia River Basin and Nested Sub Basins*, Unpublished MSc Thesis, Oregon State University, 78pp.

Brown, R.D., and Braaten, R.O., 1997: Spatial and temporal variability of Canadian monthly snow depths, 1946–1995, *Atmosphere Ocean*, 36(1): 37–54.

Bruland, O., 2002: Snow distribution at a high Arctic site at Svalbard, *Nordic Hydrology*, 32(1): 1–12.

Bryceson, D.F., and Fonseca, J., 2006: Risking death for survival: peasant responses to hunger and HIV/AIDS in Malawi, *World Development*, 34(8): 1654–1666.

Buchroithner, M.F., 1995: Problems of mountain hazard mapping using spaceborne remote sensing techniques, *Advances in Space Research*, 15(11): 57–66.

Carbutt, C., and Edwards, T.J., 2003: The flora of the Drakensberg Alpine Centre, *Edinburgh Journal of Botany*, 60: 581–607.

Carbutt, C., and Edwards, T.J., 2006: The endemic and near-endemic angiosperms of the Drakensberg Alpine Centre, *South African Journal of Botany*, 72(1): 105–132.

Cardona, O.D., 2004: The need for rethinking the concepts of vulnerability and risk from a holistic perspective: a necessary review and criticism for effective risk management, In: Bankoff, G., Frerks, G., Hilhorst, D. (Eds.), *Mapping Vulnerability: Disasters, Development and People*. Earthscan Publishers, London.

Cazorzi, F., and Fontana, G.D., 1996: Snowmelt modelling by combining air temperature and a distributed radiation index, *Journal of Hydrology*, 181:169–187.

Chakela, Q.K., 1980: Reservoir sedimentation within Roma Valley and Maliele catchments in Lesotho, *Geografiska Annaler*, 62(4): 157–169

Chakela, Q., and Stocking, M., 1988: An improved methodology for erosion hazard mapping part II: application to Lesotho, *Geografiska Annaler,* 70(3): 181–189.

Chakraborty, J., Tobin, G.A., and Montz, B.E., 2005: Population evacuation: assessing spatial variability in geophysical risk and social vulnerability to natural hazards, *Natural Hazards Review*, 6(1): 23–33.

Changnon, S.A., and Boyd, G.R., 1963: History of the Urbana weather station: 1888 – 1963, *Illinois State Weather Survey*, Circular 88, 39pp.

Chaponnière, A., Maisongrande, P., Duchemin, B., Hanich, L., Boulet, G., Escadafal, R., and Elouddat, S., 2005: A combined high and low spatial resolution approach for mapping snow covered areas in the Atlas mountains, *International Journal of Remote Sensing*, 26(13): 2755–2777.

Cherry, J.E., Tremblay, L.B., Stieglitz, M., Gong, G., and Déry, S.J., 2007: Development of the pan-arctic snowfall reconstruction: new land-based solid precipitation estimates for 1940–99, *Journal of Hydrometeorology*, 8: 1243–1263.

Cline, D.W., Bales, R.C., and Dozier, J., 1998: Estimating the spatial distribution of snow in mountain basins using remote sensing and energy balance modeling, *Water Resources Research*, 34(5): 1275–1285.

Collins, T.W., Grineski, S.E., and Aguilar, M., 2009: Vulnerability to environmental hazards in the Ciudad Jua´ rez (Mexico)–El Paso (USA) metropolis: A model for spatial risk assessment in transnational context, *Applied Geography*, 29: 448–461.

Colvin, M., and Sharp, B., 2000: Sexually transmitted infections and HIV in a rural community in the Lesotho highlands, *Sexually Transmitted Infections,* 76: 39–42.

Conner, G., 2006: *History of Weather Observations, Los Angeles, California: 1847-1948*, Midwestern Regional Climate Center, Climate Database Modernization Program, NOAA's National Climatic Data Center, Asheville, North Carolina

Corripio, J.G., 2004: Snow surface albedo estimation using terrestrial photography, *International Journal of Remote Sensing*, 25: 5705–5729.

Corripio, J.G., Durand, Y., Guyomarc'h, G., Mérindol, L., Lecorps, D., and Pugliése, P., 2004: Land-based remote sensing of snow for the validation of a snow transport model, *Cold Regions Science and Technology*, 39: 93–104.

Cova, T.J., and Church, R.L., 1997: Modelling community evacuation vulnerability using GIS, *International Journal of Geographical Information Science*, 11 (8): 763–784.

Cullen, R., Wingham, D.J., Viau, P., Francis, C.R., and Mavrocordatos, C., 2007: ESA's CryoSAT-2 multi-mode level 0 to level 1B science processors – algorithm design and pre-launch verification with ASIRAS, *Proceedings of Envisat Symposium 2007*, Montreux, Switzerland, 23–27 April 2007.

Cutter, S.L., 1996: Vulnerability to environmental hazards, *Progress in Human Geography*, 20(4): 529–539.

Cutter, S.L., Boruff, B.J., and Shirley, W.L., 2003: Social vulnerability to environmental hazards, *Social Science Quarterly*, 84(2): 242–261.

Dankers, R., and De Jong, S.M., 2004: Monitoring snow-cover dynamics in Northern Fennoscandia with SPOT VEGETATION images, *International Journal of Remote Sensing*, 25(15): 2933–2949.

Day, T., and Muller, J.P., 1989: Digital elevation model production by stereo-matching SPOT image-pairs: a comparison of algorithms, *Image and Vision Computing*, 7: 95–101.

De Angelis, H., Rau, F., and Skvarca, P., 2007: Snow zonation on Hielo Patagónico Sur, Southern Patagonia, derived from Landsat 5 TM data, *Global and Planetary Change*, 59: 149–158.

DeBeer, C.M., and Pomeroy, J.W., 2009: Modelling snow melt and snowcover depletion in a small alpine cirque, Canadian Rocky Mountains, *Hydrological Processes*, 23: 2584–2599.

Dedieu, J.P., Fortin, J.P., Savary, S., and Bernier, M., 2006: Monitoring the variation of snow cover distribution with spot-vegetation images over the French Alps during the 2000 winter season, *Geophysical Research Abstracts*, Vol. 8, 05148, 2006.

de Jong, C., 2007: Melting mountains: focus on the European Alps and beyond, *Mountain Forum Bulletin*, 7(2): 8–10.

Derksen, C., Sturm, M., Liston, G.E., Holmgren, J., Huntington, H., Silis, A., and Solie, D., 2009: Northwest Territories and Nunavut snow characteristics from a subarctic traverse: implications for passive microwave remote sensing, *Journal of Hydrometeorology*, 10: 448–463.

De Ruyter de Wildt, M., Seiz, G., and Gruen, A., 2007: Operational snow mapping using multitemporal Meteosat SEVIRI imagery, *Remote Sensing of Environment*, 109: 29–41.

Déry, S.J., Salomonson, V.V., Stieglitz, M., Hall, D.K., and Appel, I., 2005: An approach to using snow areal depletion curves inferred from MODIS and its application to land surface modelling in Alaska, *Hydrological Processes*, 19: 2755–2774.

Desnos, Y.L., Buck, C., Guijarro, J.L., Suchail, J.L., Torres, R., and Attema, E., 2000: ASAR - Envisat's Advanced Synthetic Aperture Radar, building on ERS achievements towards future Earth watch mission, *ESA Bulletin*, 102: 91−100.

Dickison, R.B.B., and Daugharty, D.A., 1980: *Effects of forest cover and topography on snow cover in central New Brunswick, Canada*, The influence of man on the hydrological regime with special reference to representative and experimental basins, Proceedings of the Helsinki Symposium, June 1980, 130: 329–335.

Dingle, R.V., Siesser, W.G., and Newton, A.R., 1983: *Mesozoic and Tertiary Geology of Southern Africa*, Rotterdam, A.A. Balkema. 375pp.

Doggett, T., Greeley, R., Chien, S., Castano, R., Cichy, B., Davies, A.G., Rabideau, G., Sherwood, R., Tran, D., Baker, V., Dohm, J., and Ip, F., 2006: Autonomous detection of cryospheric change with hyperion on-board Earth Observing-1, *Remote Sensing of Environment*, 101: 447–462.

Dozier, J., 1989: Spectral signature of Alpine snow cover from the Landsat Thematic Mapper, *Remote Sensing of Environment*, 28: 9–22.

Dozier, J., and Painter, T.H., 2004: Multispetral and hyperspectral remote sensing of Alpine snow properties, *Annual Reviews of Earth and Planetary Sciences*, 42: 465–494.

Drinkwater, M.R., Francis, R., Ratier, G. and Wingham, D.J. 2003: The European Space Agency's Earth Explorer Mission CryoSat: measuring variability in the cryosphere. *Proceedings of the Seventh International Symposium on Antarctic Glaciology (ISAG7)*, Milan, Italy, August 2003.

Dunse, T., Eisen, O., Helm, V., Steinhage, D., and Parry, V., 2008: Characteristics and small-scale variability of relation to snow accumulation in Greenland's percolation zone, *Journal of Glaciology*, 54: 333–342.

Eakin, H., and Luers, A.L., 2006: Assessing the vulnerability of social-environmental systems, *Annual Review of Environment and Resources*, 31: 365–394.

Eckert, J.B., 1983: Special focus: Lesotho's food priorities, *Food Policy – February 1983*, 76–80.

Epstein, P.R., 2004: Climate change and public health: emerging infectious diseases, *Encyclopedia of Energy*, 1: 381–392.

Espizua, L.E., and Bengochea, J.D., 2002: Landslide hazard and risk zonation mapping in the Rio Grande Basin, Central Andes of Mendoza, Argentina, *Mountain Research and Development*, 22(2): 177–185.

Esteban, P., Jones, P.D., Martín-Vide, J., and Mases, M., 2005: Atmospheric circulation patterns related to heavy snowfall days in Andorra, Pyrenees, *International Journal of Climatology*, 25: 319-329.

Etzelmüller, D., Ødegård, R.S., Sollid, J.S., 2001: Terrain parameters and remote sensing data in the analysis of permafrost distribution and periglacial processes: principles and examples from Southern Norway, *Permafrost and Periglacial Processes*, 12: 79–92.

European Space Agency, 2010: *ESA CryoSAT News Brief*. Accessed 15 July 2010: [http://www.esa.int/SPECIALS/Cryosat/SEMBC5PZVAG_0.html]

Evans, B.M., Walker, D.A., Benson, C.S., Nordstrand, E.A., and Petersen, G.W., 1989: Spatial interrelationships between terrain, snow distribution and vegetation patterns at an arctic foothills site in Alaska, *Holarctic Ecology*, 12: 270–278.

Famine Early Warning System Network (FEWSNET), 2003: *Southern Africa Food Security Brief, August/September 2003*, Hatfield, South Africa.

Famine Early Warning System Network (FEWSNET), 2006: *Southern Africa: Food Security Update, September/October 2006*, Hatfield, South Africa.

FAO, 2006: *Food Security and Agricultural Development in sub-Saharan Africa: Building a Case for More Public Support – Main Report*, Food and Agriculture Organization of the United Nations, Regional Office for Africa, Harare, Zimbabwe.

Ferguson, J., 1985: The bovine mystique: power, property and livestock in rural Lesotho, *Man*, New Series, 20(4): 647–674.

FIVIMS, 2005: *Strengthening Food Insecurity and Vulnerability Information Management in Lesotho: Assessment Report*, Maseru, Lesotho.

Fleming, A., Summerfield, M.A., Stone, J.O., Fifield, L.K., and Cresswell, R.G., 1999: Denudation rates for the southern Drakensberg escarpment, SE Africa, derived from *in-situ-* produced cosmogenic ^{36}Cl: initial results, *Journal of the Geological Society, London,* 156: 209 – 212.

Foggin, P.M., Torrance, M.E., Dorje, D., Xuri, W., Foggin, J.M., and Torrance, J., 2006: Assessment of the health status and risk factors of Kham Tibetan pastoralists in the alpine grasslands of the Tibetan plateau, *Social Science & Medicine*, 63: 2512–2532.

Foppa, N., Hauser, A., Oesch, D., Wunderle, S., and Meister, R., 2007: Validation of operational AVHRR subpixel snow retrievals over the European Alps based on ASTER data, *International Journal of Remote Sensing*, 28: 4841–4865.

FFSSA, 2004 (see Forum for Food Security in Southern Africa): *Maize, mines or manufacturing? Options for reducing hunger in Lesotho*, Country Food Security Options Paper No 1.

Foster, J.L., Hall, D.K., Eylander, J., Kim, E., Riggs, G.A., Tedesco, M., Nghiem, S., Kelly, R., Choudhury, B., and Reichle, R., 2007: Blended visible, passive-microwave and scatterometer global snow products, *Proceedings of the 64th Eastern Snow Conference*, 28 May – 1 June 2007, St. John's, Newfoundland, Canada.

Foster, J.L., Hall, D.K., Kelly, R.E.J., and Chiu, L., 2009: Seasonal snow extent and snow mass in South America using SMMR and SSM/I passive microwave data (1979–2006), *Remote Sensing of Environment*, 113: 291–305.

Freeman, H.A., Kaitibie, S., Moyo, S., and Perry, B.D., 2003: Livestock, livelihoods and vulnerability in Lesotho, Malawi and Zambia: Designing livestock interventions for emergency situations, *International Livestock Research Institute*, Research Report 8.

Gao, J., and Liu, Y., 2001: Applications of remote sensing, GIS and GPS in glaciology: a review, *Progress in Physical Geography*, 25(4): 520–540.

Gao, Y., Xie, H., Lu, N., Yao, T., and Liang, T., 2010: Toward advanced daily cloud-free snow cover and snow water equivalent products from Terra–Aqua MODIS and Aqua AMSR-E measurements, *Journal of Hydrology,* Article in Press.

Gouws, E., Stanecki, K.A., Lyerla, R., and Ghys, P.D., 2008: The epidemiology of HIV infection among young people aged 15-24 years in southern Africa, *AIDS*, 22(4): 5–16.

Government of Lesotho, 1997: State of the Environment in Lesotho, National Environment Secretariat, Ministry of Environment, Gender and Youth Affairs, Maseru, Lesotho. [http://www.lesotho.gov.ls/documents/reports/report-environ-1997.htm]

Government of Lesotho, 2005: *Lesotho Science and Technology Policy 2006-2011*, Department of Science and Technology, Maseru, Lesotho. [http://www.lesotho.gov.ls/documents/Policy%2FS_T_Policy_LESOTHO.pdf]

Grab, S., 1998: Periglacial research in Africa: past, present, future, *Progress in Physical Geography,* 22(3): 375–384.

Grab, S., 1999: Block and debris deposits in the High Drakensberg, Lesotho, Southern Africa: implications for high altitude slope processes, *Geografiska Annaler*, Series A, Physical Geography, 81(1): 1–16

Grab, S., 2000: Stone-banked lobes and environmental implications, High Drakensberg, southern Africa, *Permafrost Periglacial Process*, 11: 177–187.

Grab, S., and Nüsser, M., 2001: Towards an integrated research approach for the Drakensberg and Lesotho mountain environments: a case study from the Sani plateau region, *South African Geographical Journal*, 83(1): 64–68.

Grab, S., 2002a: Characteristics and palaeoenvironmental significance of relict sorted patterned ground, Drakensberg plateau, southern Africa, *Quaternary Science Reviews*, 21: 1729–1744.

Grab, S., 2002b: Turf exfoliation in the High Drakensberg, Southern Africa, *Geografiska Annaler*, 84A (1): 39–50.

Grab, S., 2005: Earth hummocks (thúfur): new insights to their thermal characteristics and development in eastern Lesotho, southern Africa, *Earth Surface Processes and Landforms*, 30: 541–555.

Grab, S., 2007: Rock-surface temperatures of basalt in the Drakensberg alpine environment, Lesotho, *Geografiska Annaler*, 89A (3): 185–193.

Grab, S.W., Mulder, N.A., and Mills, S.C., 2009: Spatial associations between longest-lasting winter snow cover and cold region landforms in the High Drakensberg, southern Africa, *Geografiska Annaler*, 91A(2): 1–15.

Grab, S.W., and Nash, D.J., 2010: Documentary evidence of climate variability during cold seasons in Lesotho, southern Africa, 1833–1900, *Climate Dynamics*, 34: 473–499.

Grab, S.W., and Mills, S.C., 2011: Late Quaternary slope environments in the upper Sehonghong Valley, eastern Lesotho, *Proceedings of the Geologists' Association*, 122: 179–185.

Green, R.O., Eastwood, M.L., Sarture, C.M., Chrien, T.G., Aronsson, M., Chippendale, B.J., Faust, J.A., Pavri, B.E., Chovit, C.J., Solis, M., Olah, M.R., and Williams, O., 1998: Imaging spectroscopy and the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS), *Remote Sensing of Environment*, 65: 227–248.

Green, K., and Pickering, C.M., 2009: The decline of snowpatches in the Snowy Mountains of Australia: importance of climate warming, variable snow, and wind, *Arctic, Antarctic, and Alpine Research*, 41(2): 212–218.

Groisman, P.Y., and Easterling, D.R., 1994: Variability and trends of total precipitation and snowfall over the United States and Canada, *Journal of Climate*, 7:184–205.

Gruber, U., and Bartelt, P., 2007: Snow avalanche hazard modelling of large areas using shallow water numerical methods and GIS, *Environmental Modelling & Software*, 22: 1472–1481.

Gubler, H., and Hiller, M., 1984: The use of FMCW radar in snow and avalanche research, *Cold Regions Science and Technology*, 9: 109–119.

Guillarmod, A.J., 1968: The effect of land usage on aquatic and semi-aquatic vegetation at high altitudes in Southern Africa, *Hydrobiologica*, 34(1): 1–13.

Haack, B., and English, R., 1996: National land mapping by remote sensing, *World Development,* 24(5): 845–855.

Haefner, H., Seidel, K., and Ehrler, H., 1997: Applications of snow cover mapping in high mountain regions, *Physical Chemistry of the Earth,* 22(3-4): 275-278.

Haimes, Y.Y., 2006: On the definition of vulnerabilities in measuring risks to infrastructures, *Risk Analysis*, 26(2): 293–296.

Hall, D. K., Riggs, G.A., and Salomonson, V.V., 1995: Development of methods for mapping global snow cover using moderate resolution imaging spectroradiometer data, *Remote Sensing of Environment*, 54: 127–140.

Hall, D.K., Foster, J.L., Verbyla, D.L., Klein, A.G., and Benson, C.S., 1998: Assessment of snow-cover mapping accuracy in a variety of vegetation-cover densities in central Alaska, *Remote Sensing of Environment*, 66: 129–137.

Hall, D.K., Foster, J.L., Salomonson, V.V., Klein, A.G., and Chien, J.Y.L., 2001: Development of a technique to assess snow-cover mapping errors from space, *IEEE Transactions on Geoscience and Remote Sensing*, 39: 432–438.

Hall, D.K., Riggs, G.A., Salomonson, V.V., DiGirolamo, N.E., and Bayr, K.J., 2002: MODIS snow-cover products, *Remote Sensing of Environment*, 83: 181–194.

Hall, D. K., and Riggs, G.A., 2007: Accuracy assessment of the MODIS snow products, *Hydrological Processes*, 21: 1534–1547.

Hall, D.K., Riggs, G.A., Foster, J.L., and Kumar, S.V., 2010: Development and evaluation of a cloud-gap-filled MODIS daily snow-cover product, *Remote Sensing of Environment*, 114: 496–503.

Haq, M., 2008: *Snowmelt runoff investigation in River Swat upper basin using snowmelt runoff model, remote sensing and GIS techniques*, unpublished MSc dissertation, International Institute for Geo-Information Science and Earth Observation, The Netherlands.

Hardy, D.R., Vuille, M., Braun, C., Keimig, F., and Bradley, R.S., 1998: Annual and daily meteorological cycles at high altitude on a tropical mountain, *Bulletin of the American Meteorological Society*, 79: 1899-1913.

Harper J.T., and Bradford, J.H., 2003: Snow stratigraphy over a uniform depositional surface: spatial variability and measurement tools, *Cold Regions Science and Technology*, 37: 289–298.

Harshburger, B.J., Humes, K.S., Walden, V.P., Blandford, T.R., Moore, B.C., and Dezzani, R.J., 2010: Spatial interpolation of snow water equivalency using surface observations and remotely sensed images of snow-covered area, *Hydrological Processes*, 24: 1285–1295.

Hejcman, M., Dvorak, I.J., Kocianova, M., Pavlu, V., Nezercova, P., Vitek, O., Rauch, O., and Jenik, J., 2006: Snow depth and vegetation pattern in a late-melting snowbed analyzed by GPS and GIS in the Giant Mountains, Czech Republic, *Arctic, Antarctic and Alpine Research*, 38: 90–98.

Heltberg, R., Jorgensen, S.L., and Siegel, P.B., 2008: *Climate Change, Human Vulnerability, and Social Risk Management*, Workshop on Social Aspects Of Climate Change, at the World Bank Headquarters in Washington D.C., March 5-6, 2008, 53pp.

Heltberg, R., Siegel, P.B., and Jorgensen, S.L., 2009: Addressing human vulnerability to climate change: toward a ‘no-regrets’ approach, *Global Environmental Change*, 19: 89–99.

Hiemstra, C.A., Liston, G.E., and Reiners, W.A., 2002: Snow redistribution by wind and interactions with vegetation at upper treeline in the Medicine Bow Mountains, Wyoming, U.S.A., *Arctic, Antarctic, and Alpine Research*, 34: 262–273.

Hilliard, O.M., and Burtt, B.L., 1987: The Botany of the Southern Natal Drakensberg. In: Eloff, J.N. (ed.). *Annals of Kirstenbosch Botanic Gardens*, Volume 15, Cape Town.

Hinkler, J., Pedersen, S.B., Rasch, M., and Hansen, B.U., 2002: Automatic snow cover monitoring at high temporal and spatial resolution, using images taken by a standard digital camera, *International Journal of Remote Sensing*, 23: 4669–4682.

Holmlund, P., 1996: Maps of Storglaciären and their use in glacier monitoring studies, *Geografiska Annaler*, 78: 193–196.

Hock, R., 2003: Temperature index melt modelling in mountain areas, *Journal of Hydrology*, 282: 104–115.

Holub, M., and Fuchs, S., 2009: Mitigating mountain hazards in Austria – legislation, risk transfer, and awareness building, *Natural Hazards and Earth Systems Science*, 9: 523–537.

Hood, J., and Hayashi, M., 2010: Assessing the application of a laser rangefinder for determining snow depth in inaccessible alpine terrain, *Hydrology and Earth Systems Science Discussions*, 7: 417–440.

Howe, C.W., and Cochrane, H.C., 1976: A decision model for adjusting to natural hazard events with application to urban snow storms, *The Review of Economics and Statistics*, 58(1): 50–58.

Hydén, L., 2002: The influence on summer rainfall in the Lesotho lowlands from Indian Ocean SSTs, *Nordic Hydrology*, 33(4): 305–318.

IFRC, 2005: *Southern Africa: Food Insecurity,* Information Bulletin No.01/2005, International Federation of Red Cross and Red Crescent Societies.

IFRC, 2008: *Afghanistan: Severe Winter,* Information Bulletin No.01/2008, International Federation of Red Cross and Red Crescent Societies, [http://www.glidenumber.net/glide/public/search/details.jsp?glide=18089&record=1&last=63], Accessed September 5th 2008.

Immerzeel, W.W., 2007: The effects of global warming on the Brahmaputra River Basin, *Mountain Forum Bulletin*, 7(2): 7–8.

IPCC, 2007: Summary for Policymakers. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the*

Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

ISDR 2004: *Terminology: basic terms of disaster risk reduction.* [http://www.unisdr.org/eng/library/lib-terminology-eng%20home.htm], International Strategy for Disaster Reduction Secretariat, Geneva.

Jaagus, J., 1997: The impact of climate change on the snow cover pattern in Estonia, *Climatic Change*, 36: 65–77.

Jain, S.K., Goswami, A., and Saraf, A.K., 2009: Role of elevation and aspect in snow distribution in western Himalaya, *Water Resources Management*, 23:71–83.

Jansa, J., 1998: A global topographic normalization algorithm for satellite images, *International Archives of Photogrammetry and Remote Sensing*, 32(7): 8–15.

Jenny, A.L., and Egal, F., 2002: *Household food security and nutrition in mountain areas: an often forgotten story*, Food and Agriculture Organization of the United Nations, Nutrition Programmes Service, Rome, Italy.

Jonas, T., Rixen, C., Sturm, M., and Stoeckli, V., 2008a: How alpine plant growth is linked to snow cover and climate variability, *Journal of Geophysical Research*, 113: 1–10.

Jonas, T., Geiger, F., and Jenny, H. 2008b: Mortality pattern of the Alpine chamois: the influence of snow–meteorological factors, *Annals of Glaciology*, 49: 56–62.

Jonas, T., Marty, C., and Magnusson, J., 2009: Estimating the snow water equivalent from snow depth measurements in the Swiss Alps, *Journal of Hydrology*, 378: 161–167.

Joyce, K.E., Belliss, S.E., Samsonov, S.V., McNeill, S.J. and Glassey, P.J., 2009: A review of the status of satellite remote sensing and image processing techniques for mapping natural hazards and disasters, *Progress in Physical Geography* 33, 183–207.

Kääb, A., 2002: Monitoring high-mountain terrain deformation from repeated air- and spaceborne optical data: examples using digital aerial imagery and ASTER data, *ISPRS Journal of Photogrammetry & Remote Sensing,* 57: 39–52.

Kääb, A., 2008: Glacier volume changes using ASTER satellite stereo and ICESat GLAS laser altimetry: a test study on Edgeøya, eastern Svalbard, *IEEE Transactions on Geoscience and Remote Sensing*, 46: 2823–2830.

Karimi, H.A., and Houston, B.H., 1997: Evaluating strategies for integrating environmental models with GIS: current trends and future needs, *Computers, Environment and Urban Systems*, 20(6): 413–425.

Karnatak, H.C., Saran, S., Bhatia, K., and Roy, P.S., 2007: Multicriteria spatial decision analysis in web GIS environment, *Geoinformatica*, 11: 407–429.

Keketso, l., 2003: The mixed blessings of the Lesotho Highlands Water Project: an assessment based on local perspectives, *Mountain Research and Development*, 23(1): 7–10.

Kelly, R.E.J., Chang, A.T., Tsang, L., and Foster, J.L., 2003: A prototype AMSR-E global snow area and snow depth algorithm, *IEEE Transactions on Geoscience and Remote Sensing*, 41: 230–242.

Killick, D. J. B., 1963: An account of the plant ecology of the Cathedral Peak area of the Natal Drakensberg, *Memoirs of the Botanical Survey of South Africa*, No.34.

Killick, D.J.B: 1990: *A field guide to the flora of the Natal Drakensberg*, Johannesburg, Jonathan Ball and Ad. Publishers. 198pp.

King, L.C., 1942: *South African Scenery – A Textbook of Geomorphology*, Great Britain, Oliver and Boyd Ltd. 340pp.

Klein, A.G., Hall, D.K., and Riggs, G.A., 1998: Improving snow cover mapping in forests through the use of a canopy reflectance model, *Hydrological Processes*, 12: 1723–1744.

Knudsen, N.T., and Theakstone, W.H., 1984: Recent changes of some glaciers of East Svartisen, Norway, *Geografiska Annaler*, 66: 367–380.

Koczot, K.M., and Dettinger, M.D., 1999: GIS tool to compare simulated and remotely sensed snow-cover observations, *Proceedings, 1999 Western Snow Conference*, Lake Tahoe, California, 1–6.

Koskinen, J., Metsämäki, S., Grandell, J., Jänne, S., Matikainen, L., and Hallikainen, M., 1999: Snow monitoring using radar and optical satellite data, *Remote Sensing of Environment*, 69, 16–29.

Kravitz, J.D., Nyaphisi, M., Mandel, R., and Petersen, E., 1999: Quantitative bacterial examination of domestic water supplies in the Lesotho Highlands: water quality, sanitation, and village health, *Bulletin of the World Health Organization,* 77(10): 829–836.

Kripalani, R.H., and Kulkarni, A., 1999: Climatology and variability of historical Soviet snow depth data: some new perspectives in snow – Indian monsoon teleconnections, *Climate Dynamics*, 15: 475–489.

Kropp, J.P., Block, A., Reusswig, F., Zickveld, K., and Schellnhuber, H.J., 2006: Semiquantitative assessment of regional climate vulnerability: The North Rhine Westphalia Study, *Climate Change*, 76: 265–290.

Kunzi, K.F., Patil, S., and Rott, H., 1982: Snow-cover parameters retrieved from Nimbus-7 Scanning Multichannel Microwave Radiometer (SMMR) data, *IEEE Transactions on Geoscience and Remote Sensing*, 4: 452 – 467.

Lampkin, D.J., and Yool, S.R., 2004: Monitoring mountain snowpack evolution using near-surface optical and thermal properties, *Hydrological Processes*, 18: 3527–3542.

Larson, K.M., Gutmann, E.D., Zavorotny, V.U., Braun, J.J., Williams, M.W., and Nievinski, F.G., 2009: Can we measure snow depth with GPS receivers? *Geophysical Research Letters*, 36: doi:10.1029/2009GL039430.

Latifovic, R., Zhu, Z.L., Cihlar, J., Giri, C., and Olthof, I., 2004: Land cover mapping of North and Central America – Global Land Cover 2000, *Remote Sensing of Environment*, 89: 116–127.

Lawson, D., 2008: Infrastructure and time poverty in Lesotho, *South African Journal of Economics*, 76 (1): 77–88.

Lefebre, F., Gallée, H., van Ypersele, J.P., and Greuell, W., 2003: Modeling of snow and ice melt at ETH Camp (West Greenland): A study of surface albedo, *Journal of Geophysical Research*, 108 (8): 1–16.

Lehning, M., Bartelt, P., Brown, B., Russi, T., Stöckli, U., and Zimmerli, M., 1999: SNOWPACK model calculations for avalanche warning based upon a new network of weather and snow stations, *Cold Regions Science and Technology*, 30: 145–157.

Lesotho Meteorological Services (LMS), 2007a: *Special Weather Report for 21st May 2007: Extreme Cold*, Weather Office Press Release, Accessed 21 June 2008, http://www.lesmet.org.ls/Special%20Wx%20reports/Special%20Weather_Report_May2007.pdf

Lesotho Meteorological Services (LMS), 2007b: *Weather Warning: 22nd June 2007*, Weather Office Press Release, Accessed 21 June 2008, http://www.lesmet.org.ls/Special%20Wx%20reports/weather%20warning-22-06-07.pdf

Lesotho Meteorological Services (LMS), 2007c: *Weather Warning: 24th July 2007,* Weather Office Press Release, Accessed 21 June 2008, http://www.lesmet.org.ls/Special%20Wx%20reports/weather%20warning-24-07-07.pdf

Lesotho Meteorological Services (LMS), 2007d: *Warning: Weather and Your Health: 6th September 2007*, Information and Public Affairs Press Release, Accessed 22 June 2008, http://www.lesmet.org.ls/Weather%20and%20your%20health.pdf

Lesotho Meteorological Services (LMS), 2007e: *Warning: More Rainfall and Snow Expected: 8th October 2007*, Information and Public Affairs Press Release, Accessed 22 June 2008, http://www.lesmet.org.ls/Weather%20Warning%2008-10-07.pdf

Lesotho Vulnerability Assessment Committee (LVAC), 2002: *Emergency Food Security Assessment Report*, September 2002, Maseru, Lesotho.

Lesotho Vulnerability Assessment Committee (LVAC), 2004: *Livelihood Vulnerability Assessment Report*, May 2004, Maseru, Lesotho.

Levine, C., 2004: The concept of vulnerability in disaster research, *Journal of Traumatic Stress*, 17(5): 395–402.

Li, X., and Williams, M.W., 2008: Snowmelt runoff modelling in an arid mountain watershed, Tarim Basin, China, *Hydrological Processes*, DOI: 10.1002/hyp.7098.

Liang, T.G., Huang, X.D., Wu, C.X., Liu, X.Y., Li, W.L., Guo, Z.G., and Ren, J.Z., 2008: An application of MODIS data to snow cover monitoring in a pastoral area: A case study in Northern Xinjiang, China, *Remote Sensing of Environment*, 112(4): 1514–1526.

Linde, J., and Grab, S., 2008: Regional contrasts in mountain tourism development in the Drakensberg, South Africa, *Mountain Research and Development*, 28(1): 65–71.

Lundquist, J.D., Cayan, D.R., and Dettinger, M.D., 2005: Spring onset in the Sierra Nevada: when is snowmelt independent of elevation? *Journal of Hydrometeorology*, 5: 327–342.

Machguth, H., Eisen, O., Paul, F., and Hoelzle, M., 2006: Strong spatial variability of snow accumulation observed with helicopter-borne GPR on two adjacent Alpine glaciers, *Geophysical Research Letters*, 33: 1–5.

Madrid, C.R., 1978: *The Nimbus-7 User's Guide*, Greenbelt, MD: NASA Goddard Space Flight Center.

Makhanya, E.M., 2004: Demographic dynamics and land degradation at Ratau, Lesotho, in the context of rural sustainability, *Land Degradation and Development*, 15: 257–269.

Makosholo, M.L., 2005: *The comparative advantage of long-term crops in Lesotho*, Unpublished MSc Thesis, University of Free State, Bloemfontein.

Malcher, P., Floricioiu, D., and Rott, H., 2003: Snow mapping in Alpine areas using medium resolution spectrometers, *IEEE Transactions on Geoscience and Remote Sensing*, 4: 2835–2837.

Malik, A., and Hunzai, I.A., 2005: *The promise and challenge of pluralism for sustainable development in mountain areas: experience and encounters from Northern Areas and Chitral,* International Workshop Dushanbe, Tajikistan June 6–10, Paper 11.

Margreth, S., and Funk, M., 1999: Hazard mapping for ice and combined snow/ice avalanches - two case studies from the Swiss and Italian Alps, *Cold Regions Science and Technology*, 30: 159–173.

Marker, M.E., 1991: The evidence cirque glaciation in Lesotho, *Permafrost and Periglacial Processes*, 2: 21–30.

Mashinini, I.V., and De Villiers, G., 2001: Lesotho's sustainable development challenges for the 21st century: a geo-political perspective, *South African Geographical Journal*, 83(1): 56–63.

Maurer, E.P., Rhoads, J.D., Dubayah, R.O., and Lettenmaier, D.P., 2003: Evaluation of the snow-covered area data product from MODIS, *Hydrological Processes*, 17: 59–71.

Mayaux, P., Bartholomé, E., Massart, M., Van Cutsem, C., Cabral, A., Nonguierma, A., Diallo, O., Pretorius, C., Thompson, M., Cherlet, M., Pekel, J-F., Defourny, P., Vasconcelos, M., Di Gregario, A., Ftitz, S., De Grandi, G., Elvidge, C., Vogt, P., and Belward, A., 2003: *A Land Cover Map of Africa*, European Commission Joint Research Centre.

Ministry of Natural Resources, 2000: *National Report on Climate Change,* Lesotho Meteorological Services, Maseru.

Mishra, V.D., Sharma, J.K., and Khanna, R., 2010: Review of topographic analysis methods for the western Himalaya using AWiFS and MODIS satellite imagery, *Annals of Glaciology*, 51(54): 153–160.

Mock, N., 2005: *Vulnerability Assessment Methodology Review: Lesotho Country Report*, The Southern Africa Development Community: Food, Agriculture and Natural Resources, Regional Vulnerability Assessment Committee (SADC–FANR RVAC).

Mokotjomela, T., Schwaibold, U., and Pillay, N., 2009: Does the ice rat *Otomys sloggetti robertsi* contribute to habitat change in Lesotho? *Acta Oecologica*, 35: 437–443.

Molapo, S.P., 2009: *Community vulnerability to food insecurity – a case study of the World Food Programme (WFP) food aid programme in the southern lowlands of Lesotho*, Unpublished Masters Thesis, Stellenbosch University.

Molotch, N.P., and Bales, R.C., 2006: Comparison of ground-based and airborne snow surface albedo parameterizations in an alpine watershed: impact on snowpack mass balance, *Water Resources Research*, 42: 1–12.

Molotch, N.P., and Margulis, S.A., 2008: Estimating the distribution of snow water equivalent using remotely sensed snow cover data and a spatially distributed snowmelt model: a multi-resolution, multi-sensor comparison, *Advances in Water Resources*, 31: 1503–1514.

Monyooe, L.A., 1994: Primary agriculture curriculum in Lesotho: a demarcation of imperatives, *International Journal of Educational Development*, 14(4): 351–360.

Moore, A., and Blenkinsop, T., 2006: Scarp retreat versus pinned drainage divide in the formation of the Drakensberg escarpment, southern Africa, *South African Journal of Geology*, 109:599–610.

Moseley, W., and Earl, J., 1997: *Final RiskMap Report: Lesotho*, Save the Children Fund, UK.

Mphale, M.M., Rwambali, E.G., and Makoae, M.G., 2002: HIV/AIDS and its impact on land tenure and livelihoods in Lesotho, *Produced for the Food and Agriculture Organization of the United Nations*, Lesotho, March 2002.

Mulder, N.A.M., 2007: *Snow cover analysis for the high Drakensberg through remote sensing: environmental implications*, Unpublished Masters Thesis, University of the Witwatersrand, Johannesburg.

Mulder, N., and Grab, S.W., 2002: Remote sensing for snow cover analysis along the Drakensberg escarpment, *South African Journal of Science*, 98: 213– 216.

Mulder, N., and Grab, S.W., 2009: Contemporary spatio-temporal patterns of snow cover over the Drakensberg, *South African Journal of Science*, 105: 228–233.

Mulders, M.A., 2001: Advances in the application of remote sensing and GIS for surveying mountainous land, *Journal of Applied Earth Observation and Geoinformation*, 3(1): 3–10.

Nagler, T., and Rott, H., 2000: Retrieval of wet snow by means of multitemporal SAR data, *Transactions on Geoscience and Remote Sensing*, 38: 754–765.

Nagler, T., Rott, H., Malcher, P., and Müller, F., 2008: Assimilation of meteorological and remote sensing data for snowmelt runoff forecasting, *Remote Sensing of Environment*, 112: 1408–1420.

NAPA, 2006: *Lesotho's National Adaptation Programme of Action on Climate Change*, Ministry of Natural Resources, Lesotho Meteorological Services.

Nash, D.J., and Grab, S.W., 2009: "A sky of brass and burning winds": documentary evidence of rainfall variability in the Kingdom of Lesotho, Southern Africa, 1824–1900, *Climatic Change*, DOI 10.1007/s10584-009-9707-y.

National Climatic Data Center (NCDC), 2002: *Climate of 2002: Preliminary Annual Review of Significant U.S. and Global Events,* National Oceanic and Atmospheric Administration, http://www.hprcc.unl.edu/nebraska/significant-events2002.html.

Negi, H., Thakur, N., Kumar, R., and Kumar, M., 2009: Monitoring and evaluation of seasonal snow cover in Kashmir valley using remote sensing, GIS and ancillary data, *Journal of Earth Systems Science*, 118: 711-720.

Nel, W., and Sumner, P.D., 2005: First rainfall data from the KZN Drakensberg escarpment edge (2002 and 2003), *Water SA*, 31(3): 399–402.

Nel, W., 2008: Observations on daily rainfall events in the KwaZulu-Natal Drakensberg, *Water SA*, 34 (2): 271–274.

Nel, W., and Sumner, P.D., 2008: Rainfall and temperature attributes on the Lesotho–Drakensberg escarpment edge, southern Africa, *Geografiska Annaler*, 90A (1): 97–108.

Nel, W., Reynhardt, D.A., and Sumner, P.D., 2010: Effect of altitude on erosive characteristics of concurrent rainfall events in the northern KwaZulu-Natal Drakensberg, *Water SA*, 36(4): 509–512.

Nolin, A.W., and Dozier, J., 1993: Estimating snow grain size using AVIRIS data, *Remote Sensing of Environment*, 44: 231–238.

Nolin, A.W., and Dozier, J., 2000: A hyperspectral method for remotely sensing the grain size of snow, *Remote Sensing of Environment,* 74:207–216.

Nyabanyaba, T, 2008: *The use of Open, Distance and Flexible Learning (ODFL) initiatives to open up access to education in the context of HIV and AIDS prevalence rates: the case of Lesotho*, SOFIE Opening Up Access Series 4, Institute of Education, University of London. [http://www.research4development.info/PDF/Outputs/ESRC_DFID/60431-NyabanyabaPaper4.pdf]

Oberoi, S.V., and Thakur, N.K., 2005: *Disaster preparedness in the hills: natural hazard modeling using GIS and remote sensing*, Proceedings of the 2005 ASCE International Conference on Computing in Civil Engineering, Cancun, Mexico, 12–15 July, Paper #8741.

Obioha, E.E., 2010: Climate variability and food production nexus in Lesotho, 2001 – 2007, *Journal of Human Ecology*, 32(3): 149–160.

O'Brien, K., Quinlan, T., and Ziervogel, G., 2009: Vulnerability interventions in the context of multiple stressors: lessons from the Southern Africa Vulnerability Initiative (SAVI), *Environmental Science and Policy*, 12: 23–32.

Oesch, D., Wunderle, S., and Hauser, A., 2002: *Snow surface temperature from AVHRR as a proxy for snowmelt in the Alps*, Proceedings of EARSeL–LISSIG–Workshop Observing our Cryosphere from Space, Bern, March 11 – 13, 2002, 163–169.

Painter, T.H., Roberts, D.A., Green, R.O., and Dozier, J., 1998: The effect of grain size on spectral mixture analysis of snow-covered area from AVIRIS data, *Remote Sensing of Environment*, 65:320–332.

Painter, T.H., Dozier, J., Roberts, D.A., Davis, R.E., and Green, R.O., 2003: Retrieval of subpixel snow-covered area and grain size from imaging spectrometer data, *Remote Sensing of Environment*, 85: 64–77.

Palacios, D., de Andrés, N., and Luengo, E., 2003: Distribution and effectiveness of nivation in Mediterranean mountains: Peñalara (Spain), *Geomorphology*, 54: 157–178.

Parajka, J., and Blöschl, G., 2008: Spatio-temporal combination of MODIS images – potential for snow cover mapping, *Water Resources Research*, 44: W03406.

Parajka, J., Pepe, M., Rampini, A., Rossi, S., and Blöschl, G., 2009: A regional snow-line method for estimating snow cover from MODIS during cloud cover, *Journal of Hydrology*, 381: 203–212.

Partridge, T.C., 1998: Of diamonds, dinosaurs and diastrophism: 150 million years of landscape evolution in southern Africa, *South African Journal of Geology,* 101(3): 167 – 184.

Patz, J.A., Campbell–Lendrum, D., Holloway, T., and Foley, J.A., 2005: Impact of regional climate change on human health, *Nature*, 438(17): 310–317.

Pearlman, J.S., Barry, P.S., Segal, C.C., Shepanski, J., Beiso, D., and Carman, S.L., 2003: Hyperion, a space-based imaging spectrometer, *IEEE Transactions on Geoscience and Remote Sensing*, 41: 1160–1173.

Pecci, M., 2007: The central Mediterranean cryosphere in a changing mountain environment, *Mountain Forum Bulletin*, 7(2): 15–16.

Pepe, M., Brivio, P.A., Rampini, A., Rota, N.F., and Boschetti, M., 2005: Snow cover monitoring in Alpine regions using ENVISAT optical data, *International Journal of Remote Sensing*, 26: 4661–4667.

Pettinato, S., Poggi, P., Macelloni, G., Paloscia, S., Pampaloni, P., and Crepaz, A., 2004: Mapping snow cover in Alpine areas with ENVISAT/SAR images, *Proceedings of the 2004 Envisat & ERS Symposium*, Salzburg, Austria 6–10 September 2004.

Pezza, A., and Ambrizzi, T., 2005: Dynamical conditions and synoptic tracks associated with different types of cold surge over tropical South America, *International Journal of Climatology*, 25: 215–241.

Pielmeier C., and Schneebeli, M., 2003: Developments in the stratigraphy of snow, *Surveys in Geophysics*, 24: 389–416.

Pinheiro, A.C.T., Descloitres, J., Privette, J.L., Susskind, J., Iredell, L., and Schmaltz, J., 2007: Near-real time retrievals of land surface temperature within the MODIS Rapid Response System, *Remote Sensing of Environment*, 106: 326–336.

Pinto, J.G., Brücher, T., Fink, A.H., and Krüger, A., 2007: Extraordinary snow accumulations over parts of central Europe during the winter of 2005/06 and weather-related hazards, *Weather*, 62(1): 16–21.

Piot, P., Bartos, M., Larson, H., Zewdie, D., and Mane, P., 2008: Coming to terms with complexity: a call to action for HIV prevention, *Lancet*, 372: 845–859.

Podolskiy, E.A., Nishimura, K., Osamu, A.B.E., and Chernous, P.A., 2010: Earthquake–induced snow avalanches: historical case studies, *Journal of Glaciology*, 56(197): 431–446.

Polsky, C., Schröter, D., Patt, A., Gaffin, S., Martello, M.L., Neff, R., Pulsipher, A., and Selin, H., 2003: *Assessing Vulnerabilities to the Effects of Global Change: An Eight-Step Approach*, Belfer Center for Science & International Affairs, 3:1–19.

Preston–Whyte, R.A., and Tyson, P.D., 1988: *The Atmosphere and Weather of Southern Africa*, Oxford University Press, Cape Town, 374pp.

Prior, J., and Kendon, M., 2011: The UK winter of 2009/2010 compared with severe winters of the last 100 years, *Weather*, 66(1): 4–10.

Prudent, G., 2007: Overview of climatic change impacts in the European Alps, *Mountain Forum Bulletin,* 7(2): 12–14.

Quinlan, T., 1995: Grassland degradation and livestock rearing in Lesotho, *Journal of Southern African Studies*, 21(3): 491–507.

Rabuffetti, D., Ravazzani, G., Corbari, C., and Mancini, M., 2008: Verification of operational Quantitative Discharge Forecast (QDF) for a regional warning system – the AMPHORE case studies in the upper Po River, *Natural Hazards and Earth Systems Sciences*, 8: 161–173.

Ramsay, B.H., 1998: The interactive multisensor snow and ice mapping system, *Hydrological Processes*, 12: 1537–1546.

Reed, B., Budde, M., Spencer P., and Miller, A.E., 2009: Integration of MODIS-derived metrics to assess interannual variability in snowpack, lake ice, and NDVI in southwest Alaska, *Remote Sensing of Environment*, 113: 1443–1452.

Reid, P., and Vogel, C., 2006: Living and responding to multiple stressors in South Africa–glimpses from KwaZulu-Natal, *Global Environmental Change*, 16: 195–206.

Renzaho, A.M.N., 2006: Mortality, malnutrition and the humanitarian response to the food crises in Lesotho, *Journal of Emergency Primary Health Care*, 4(4).

Rhoades, R.E., and Thompson, S.I., 1975: Adaptive strategies in Alpine environments: beyond ecological particularism, *American Ethnologist*, 2(3): 535–551.

Richardson, S.D., and Reynolds, J.M., 2000: An overview of glacial hazards in the Himalayas, *Quaternary International*, 65/66: 31–47.

Riebsame, W.E., Diaz, H.F., Moses, T., and Price, M., 1986: The social burden of climate hazards, *Bulletin of the American Meteorological Society*, 67(11): 1378–1388.

Riggs, G., and Hall, D.K., 2004: *Snow mapping with the MODIS Aqua instrument*, Proceedings of the 61st Eastern Snow Conference, Portland, Maine, 2004, 81–84.

Riggs, G.A., Hall, D.K., and Salomonson, V.V., 2006: *MODIS Snow Products: User Guide to Collection*, http://nsidc.org/data/docs/daac/modis_v5/dorothy_snow_doc.pdf.

Rignot, E., Echelmeyer, K., and Krabill, W., 2001: Penetration depth of interferometric synthetic-aperture radar signals in snow and ice, *Geophysical Research Letters*, 28: 3501–3504.

Robinson, D.A., Dewey, K.F., and Heim, R.R., 1993: Global snow cover monitoring: an update, *Bulletin of the American Meteorological Society*, 74(9): 1689–1696.

Romanov, P., Gutman, G., and Csiszar, I., 2000: Automated monitoring of snow cover over North America with multispectral satellite data, *Journal of Applied Meteorology*, 39: 1866–1880.

Romero-Daza, M., Himmelgreen, D.A., Noble, C.A., and Turkon, D., 2009: Dealing with the global food crisis in local settings: nonintensive agriculture in Lesotho, southern Africa, *NAPA Bulletin*, 32: 23–41.

Rooney, J.F., 1967: The urban snow hazard in the United States: an appraisal of disruption, *Geographical Review*, 57(4): 538–559.

Rosenthal, W., and Dozier, J., 1996: Automated mapping of montane snow cover at subpixel resolution from the Landsat Thematic Mapper, *Water Resources Research,* 32: 115–130.

Rydgren, B., 1988: A Geomorphological approach to soil erosion studies in Lesotho, *Geografiska Annaler, Series A, Physical Geography*, 70(3): 255–262.

Sand, K., Winther, J.G., Maréchal, D., Bruland, O., and Melvold, K., 2003: Regional variations of snow accumulation on Spitsbergen, Svalbard, 1997–99, *Nordic Hydrology*, 34: 17–32.

Safilios–Rothschild, C., 1985: The Persistence of Women's Invisibility in Agriculture: Theoretical and Policy Lessons from Lesotho and Sierra Leone, *Economic Development and Cultural Change*, 33(2): 299–317.

Salomonson, V.V., and Appel, I., 2004: Estimating fractional snow cover from MODIS using the normalized difference snow index, *Remote Sensing of Environment*, 89: 351–360.

Salomonson, V.V., and Appel, I., 2006: Development of the Aqua MODIS NDSI fractional snow cover algorithm and validation results, *IEEE Transactions on Geoscience and Remote Sensing*, 44(7): 1747–1756.

Schmidlin, T., 1989: Climatic summary of snowfall and snow depth in the Ohio snowbelt at Chardon, *Ohio Journal of Science*, 89: 101–108.

Schmitz, G., and Rooyani, F., 1987: *Lesotho – Geology, Geomorphology, Soils*, National University of Lesotho, Roma, 204pp.

Schulz, O., and de Jong, C., 2004: Snowmelt and sublimation: field experiments and modelling in the High Atlas Mountains of Morocco, *Hydrology and Earth System Sciences*, 8 (6): 1076–1089.

Schulze, B.E., Zwally, H.J., Shuman, C.A., Hancock, D., and DiMarzio, J.P., 2005: Overview of the ICESat mission, *Geophysical Research Letters*, 32: doi:10.1029/2005GL024009.

Seidel, T.M., Weihrauch, D.M., Kimball, K.D., Pszenny, A.A.P., Soboleski, R., Crete, E., and Murray, G., 2009: Evidence of climate change declines with elevation based on temperature and snow records from 1930s to 2006 on Mount Washington, New Hampshire, U.S.A., *Arctic, Antarctic and Alpine Research*, 41(3): 362–372.

Sene, K.J., Jones, D.A., Meigh, J.R., and Farquharson, F.A.K., 1998: Rainfall and flow variations in the Lesotho Highlands, *International Journal of Climatology*, 18: 329–345.

Shamir, E., and Georgakakos, K.P., 2007: Estimating snow depletion curves for American River basins using distributed snow modelling, *Journal of Hydrology*, 334: 162–173.

Sharma, S.S., and Ganju, A., 2000: Complexities of avalanche forecasting in Western Himalaya – an overview, *Cold Regions Science and Technology*, 31:95–102.

Shi, J., and Dozier, J., 1997: Mapping seasonal snow with SIR–C/X–SAR in mountainous areas, *Remote Sensing of Environment*, 59: 294–307.

Showers, K.B., and Malahleha, G.M., 1992: Oral evidence in historical environmental impact assessment: soil conservation in Lesotho in the 1930s and 1940s, *Journal of Southern African Studies*, 18 (2): 276–296.

Shroyer, M.E., and Blignaut, P., 2003: Mountain conservation in South Africa, *USDA Forest Service Proceedings*, RMRS–P–27: 26–33.

Sieben, E.J.J., Morris, C.D., Kotze, D.C., and Muasya, A.M., 2010: Changes in plant form and function across altitudinal and wetness gradients in the wetlands of the Maloti-Drakensberg, South Africa, *Plant Ecology*, 207:107–119.

Silverio, W., and Jaquet, J.M., 2005: Glacial cover mapping (1987–1996) of the Cordillera Blanca (Peru) using satellite imagery, *Remote Sensing of Environment*, 95: 342–350.

Simic, A., Fernandes, R., Brown, R., Romanov, P., and Park, W., 2004: Validation of VEGETATION, MODIS, and GOES+ SSM/I snow-cover products over Canada based on surface snow depth observations, *Hydrological Processes*, 18: 1089–1104.

Singh, P., 2003: Relating air temperatures to the depletion of snow covered area in a Himalayan basin, *Nordic Hydrology*, 34(4): 267–280.

Sirguey, P., Mathieu, R., Arnaud, Y., Khan, M.M., and Chanussot, J., 2008: Improving MODIS spatial resolution for snow mapping using wavelet fusion and ARSIS concept, *IEEE Geoscience and Remote Sensing Letters*, 5: 78–82.

Smit, B., and Wandel, J., 2006: Adaptation, adaptive capacity and vulnerability, *Global Environmental Change*, 16: 282–292.

Solberg, R., 2000: A new method for sub-pixel snow-cover mapping using hyperspectral imagery – first results, *Proceedings of EARSeL-SIG-Workshop Land Ice and Snow, Dresden/FRG, June 16 – 17, 2000*, pp255–264.

Sorman, A.Ü., Akyürek, Z., Sensoy, A., Sorman, A.A., and Tekeli, A.E., 2007: Commentary on comparison of MODIS snow cover and albedo products with ground observations over the mountainous terrain of Turkey, *Hydrology and Earth Systems Sciences*, 11: 1353–1360.

Southern Africa Development Community (SADC), 2002: *Regional Emergency Food Security Assessment Report*, Food, Agriculture and Natural Resources Vulnerability Assessment Committee, September 2002, Harare, Zimbabwe.

Southern Africa Development Community (SADC), 2004: *Regional Food Security Programme: Special AgroMet Update,* Regional Remote Sensing Unit, Harare, Zimbabwe.

Southern Africa Development Community (SADC), 2007: *Regional Food Security Programme: Growing Season Status 2006/07*, Issue 3, SADC Secretariat, Gabarone, Botswana.

Sovilla, B., McElwaine, J., Schaer, M., and Vallet, J., 2010: Variation of deposition depth with slope angle in snow avalanches: measurements from Vallée de la Sionne, *Journal of Geophysical Research*, Article in Press.

Srinivasan, A., 2000: Strategies for seasonal climate risk management in subsistence agriculture, *International Forum on Climate Prediction, Agriculture and Development,* 278–288.

Storvold, R., Malnes, E., and Lauknes, I., 2005: Using ENVISAT ASAR wideswath data to retrieve snow covered area in mountainous regions, *EARSeL eProceedings*, 4: 150–156.

Stowell Bracke, M., Miller, C.C., and Kim, J., 2008: Adding value to digitising with GIS, *Library Hi Tech*, 26(2): 201–212.

Sumner, P., 2003: A contemporary winter ground thermal profile in the Lesotho Highlands and implications for active and relict soil frost phenomena, *Earth Surface Processes and Landforms*, 28: 1451–1458.

Sumner, P.D., and Nel, W., 2006: Surface-climate attributes at Injisuthi Outpost, Drakensberg, and possible ramifications for weathering, *Earth Surface Processes and Landforms*, 31:1445–145.

Swallow, B., 2003: *The role of mobility within the risk management strategies of pastoralists and agro-pastoralists*, International Institute for Environment and Development, Gatekeeper Series, No. SA47.

Tachiiri, K., Shinoda, M., Klinkenberg, B., and Morinaga, Y., 2008: Assessing Mongolian snow disaster risk using livestock and satellite data, *Journal of Arid Environments*, 72: 2251–2263.

Taele, B.M., Gopinathan, K.K., and Mokhuts'oane, L., 2007: The potential of renewable energy technologies for rural development in Lesotho, *Renewable Energy*, 32: 609–622.

Tampellini, M.L., Brivio, P.A., Carrara, P., Fantoni, D., Gnocchi, S., Ober, G., Pepe, M., Rampini, A., Ratti, R., Nodari, F.R., and Strozzi, T., 2004: Monitoring snow cover in Alpine regions through the integration of MERIS and AATSR ENVISAT satellite observations, *Proceedings of MERIS User Workshop*, Frascati, Italy, 10 – 13 November 2003.

Tappeiner, U., Tappeiner, G., Aschenwald, J., Tasser, E., and Ostendorf, B., 2001: GIS-based modelling of spatial pattern of snow cover duration in an alpine area, *Ecological Modelling*, 138: 265–275.

Tekeli, A.E., Akyurek, Z., Sorman, A.A., Sensoy, A., and Sorman, A. Ü., 2005: Using MODIS snow cover maps in modeling snowmelt runoff process in the eastern part of Turkey, *Remote Sensing of Environment*, 97: 216–230.

Thornton, P.K., Jones, P.G., Owiyo, T., Kruska, R.L., Herrero, M., Orindi, V., Bhadwal, S., Kristjanson, P., Notenbaert, A., Bekele N., and Omolo, A., 2008: Climate change and poverty in Africa: mapping hotspots of vulnerability, *AfJARE*, 2(1): 24–44.

Tong, J., Déry, S.J., and Jackson, P.L., 2008: Topographic control of snow distribution in an alpine watershed of western Canada inferred from spatially-filtered MODIS snow products, *Hydrology and Earth System Sciences Discussions*, 5: 2347–2371.

Truswell, J.F., 1977: *The Geological Evolution of South Africa*, Purnell & Sons, Cape Town, South Africa, 214pp.

Turner, S., 2001: CARE Lesotho, *Livelihoods in Lesotho*, Livelihoods Recovery through Agriculture Programme (LRAP), Amsterdam, 1–15.

Turner, S., 2003: CARE Lesotho, *Livelihood Trends in Lesotho: A Review of the Last Two Decades*, LRAP Discussion Paper No. 1, Amsterdam, 1–82.

Turner, B.L., Kasperson, R.E., Matson, P.A., McCarthy, J.J., Corell, R.W., Christensen, L., Eckley, N., Kasperson, J.X., Luers, A., Martello, M.L., Polsky, C., Pulsipher, A., and Schiller, A., 2003: A framework for vulnerability analysis in sustainability science, *PNAS*, 100(14): 8074–8079.

Tyson, P. D., Preston-Whyte, R. A., and Schulze, R. E., 1976: *The Climate of The Drakensberg*, Natal Town and Regional Planning Commission, Pietermaritzburg.

Tyson, P.D., 1986: *Climatic Change and Variability in Southern Africa*, Oxford University Press, Cape Town.

UNCTAD, 2003: Investment Policy Review: Lesotho, *United Nations Conference on Trade and Development*, [http://www.unctad.org/en/subsites/dite/index.html] Accessed 25th October 2006.

UNDP, 2007: *Making Globalization Work for All*, United Nations Development Programme, Annual Report, New York.

United Nations Inter-Agency Coordination Support Office (UNRIACSO), 2004: *Southern African Humanitarian Crisis Update*, Monthly Update, November 2004.

Vajjhala, S.P. and Walker, W.M., 2009: *Integrating cognitive mapping and GIS for transport prioritization in rural Lesotho*, Discussion Paper 09-26, Resources for the Future, Washington D.C.

Van Zinderen Bakker, E.M., and Werger, M.J.A., 1974: Environment, vegetation and phytogeography of the high-altitude bogs of Lesotho, *Vegetation*, 29: 37–49.

Vieira, G.T., Mora, C., and Ramos, M., 2003: Ground temperature regimes and geomorphological implications in a Mediterranean mountain (Serra da Estrela, Portugal), *Geomorphology*, 52: 57–72.

Vikhamar, D., and Solberg, R., 2002: Subpixel mapping of snow cover in forests by optical remote sensing, *Remote Sensing of Environment*, 84: 69–82.

Vuille, M., and Ammann, C., 1997: Regional snowfall patterns in the high, arid Andes, *Climatic Change*, 36: 413–423.

Wallman, S., 1972: Conditions of non-development: the case of Lesotho, *Journal of Development Studies*, 8(2): 251–261.

Wang, L., Qu, J.J., Xiong, X., Hao, X., Xie, Y., and Che, N., 2006: A new method for retrieving band 6 of Aqua MODIS, *IEEE Geoscience and Remote Sensing Letters*, 3: 1545–1598.

Whetton, P.H., Haylock, M.R., and Galloway, R., 1996: Climate change and snow-cover duration in the Australian Alps, *Climate Change*, 32: 447–479.

Xiao, G., Zhang, Q., Yao, Y., Zhao, H., Wang, R., Bai, H., and Zhang, F., 2008: Impact of recent climatic change on the yield of winter wheat at low and high altitudes in semi-arid northwestern China, *Agriculture, Ecosystems and Environment*, 127: 37–42.

Yi, D., Zwally, H.J., and Robbins, J.W., 2011: ICESat observations of seasonal and interannual variations of sea-ice freeboard and estimated thickness in the Weddell Sea, Antarctica (2003–2009), *Annals of Glaciology*, 52(57): 43–51.

Yohay, C., and Ronen, K., 1998: Computerized classification of Mediterranean vegetation using panchromatic aerial photographs, *Journal of Vegetation Science*, 9: 445–454.

Zerger, A., 2002: Examining GIS decision utility for natural hazard risk modelling, *Environmental Modelling and Software,* 17: 287–294.

Zerger, A., and Smith, D.I., 2003: Impediments to using GIS for real-time disaster support, *Computers, Environment and Urban Systems*, 27:123–141.

Ziervogel, G., and Calder, R., 2003: Climate variability and rural livelihoods: assessing the impact of seasonal climate forecasts in Lesotho, *Area*, 35(4): 403–417.

Ziervogel, G., 2004: Targeting seasonal climate forecasts for integration into household level decisions: the case of smallholder farms in Lesotho, *The Geographical Journal*, 170 (1): 6–21.

Ziervogel, G., Bithell, M., Washington, R., Downing, T., 2005: Agent-based social simulation: a method for assessing the impact of seasonal climate forecast applications among smallholder farmers, *Agricultural Systems*, 83: 1–26.

Ziervogel, G., Nyong, A., Osman, B., Conde, C., Cortés, S. and Downing, T., 2006: Climate variability and change: implications for household food security, *AIACC Working Paper No. 20*, January 2006.

Zwally, H.J., Schutz, B., Abdalati, W., Abshire, J., Bentley, C., Brenner, A., Bufton, J., Dezio, J., Hancock, D., Harding, D., Herring, T., Minster, B., Quinn, K., Palm, S., Spinhirne, J., and Thomas, R., 2002: ICESat's laser measurements of polar ice, atmosphere, ocean, and land, *Journal of Geodynamics*, 34: 405–445.

Appendix 1

Vulnerability Rankings

Each village has a ranking based on its proximity to the nearest road (major or secondary), the mean and maximum duration of snow cover on the nearest road, and the mean and maximum duration of snow cover experienced by the village following early, mid and late season snowfalls. Villages are assigned ranks of 0 – 8, according to their scores based on the 5 vulnerability indicators. The overall vulnerability of villages to the negative impacts associated with prolonged snow cover is expressed as a ranking from 0 – 40. Overall seasonal vulnerability rankings are basically a sum of the scores based on the 5 vulnerability indicators.

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Anone	Quthing	**M**	5.56	2	0	0	1	1	4	8	4	4	**15**	0	0	0	0	**1**	0	0	0	0	**3**
Aupolasi	Mokhotlong	**S**	0.23	1	2	2	3	3	2	4	3	3	**14**	0	0	0	0	**4**	0	0	0	0	**1**
Bafali	Mafeteng	**M**	25.01	7	0	0	0	0	1	2	1	1	**10**	0	0	0	0	**2**	0	0	0	0	**1**
Bahaoleng	Thaba-Tseka	**M**	3.18	1	0	0	3	3	1	2	3	3	**9**	0	0	1	1	**14**	0	0	0	0	**1**
Bakaneng	Quthing	**S**	0.59	1	0	0	3	3	1	2	3	3	**10**	0	0	0	0	**4**	0	0	0	0	**1**
Baruting	Mohale's Hoek	**S**	0.24	1	0	0	3	3	0	0	3	3	**8**	0	0	1	1	**3**	0	0	0	0	**1**
Basieng	Qacha's Nek	**M**	2.08	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Bela-Bela	Mokhotlong	**M**	4.40	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**5**	0	0	0	0	**1**
Beresi	Mokhotlong	**M**	13.35	4	1	1	1	1	0	0	1	1	**7**	0	0	0	0	**2**	0	0	0	0	**1**
Beselateng	Leribe	**M**	4.79	2	0	0	2	2	0	0	0	0	**4**	0	0	1	1	**7**	0	0	0	0	**3**
Biafa	Berea	**M**	0.36	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	0	0	**2**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Bloodberg	Quthing	**M**	3.32	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**5**	0	0	0	0	**1**
Blue Gums	Berea	**M**	9.06	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**1**
Boalathapo	Thaba-Tseka	**M**	0.18	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Bobatsi	Qacha's Nek	**M**	19.07	6	0	0	1	1	0	0	1	1	**8**	0	0	1	1	**5**	0	0	0	0	**1**
Bobete	Mohale's Hoek	**M**	9.60	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**3**	0	0	1	1	**3**
Bochabe	Mokhotlong	**M**	18.73	5	0	0	1	1	0	0	0	0	**6**	0	0	1	1	**3**	0	0	0	0	**2**
Bochabela Ha Setenane	Mohale's Hoek	**M**	0.68	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**3**
Bocheletsane	Butha-Buthe	**M**	10.75	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**5**	0	0	0	0	**1**
Boiketlo	Mokhotlong	**M**	8.43	3	0	0	2	2	0	0	1	1	**2**	0	0	0	0	**2**	0	0	0	0	**1**
Boiketlo	Thaba-Tseka	**M**	4.86	2	0	0	0	0	0	0	0	0	**6**	0	0	0	0	**2**	0	0	0	0	**3**
Boinyatso	Leribe	**M**	2.14	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**9**	0	0	1	1	**4**
Boitelo	Mafeteng	**M**	3.91	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**3**	0	0	0	0	**1**
Boithatelo	Thaba-Tseka	**M**	8.40	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**3**
Bokhina-Pere	Butha-Buthe	**M**	1.54	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**10**	0	0	0	0	**3**
Bokhoasa	Mokhotlong	**S**	0.73	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**2**	0	0	0	0	**1**
Bolahla Ha Litau	Butha-Buthe	**M**	1.69	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Bolanku	Mohale's Hoek	**M**	10.06	3	0	0	0	0	0	0	1	1	**4**	0	0	0	0	**3**	0	0	0	0	**1**
Bolikela	Leribe	**M**	3.04	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**2**
Bolula	Mokhotlong	**M**	19.31	6	2	2	3	3	0	0	0	0	**11**	0	0	0	0	**5**	0	0	0	0	**1**
Boluma-Tau	Thaba-Tseka	**M**	6.22	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**6**
Bongalla	Quthing	**M**	5.61	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**2**
Boqate Ha Makhoati	Berea	**M**	0.33	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**6**	0	0	0	0	**3**
Boritsa	Mafeteng	**M**	7.46	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**4**	0	0	0	0	**0**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Bothoba-Pelo	Quthing	**M**	0.27	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Botsola	Mafeteng	**M**	2.44	1	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**2**	0	0	0	0	**2**
Chache	Butha-Buthe	**M**	3.74	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Chaena	Maseru	**M**	0.03	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	**9**	0	0	0	0	**2**
Chafo	Mohale's Hoek	**M**	13.04	4	0	0	0	0	0	0	1	1	**5**	0	0	0	0	**1**	0	0	0	0	**1**
Daliwe Ha Sekhobe	Thaba-Tseka	**M**	5.26	2	1	1	1	1	0	0	0	0	**4**	0	0	0	0	**6**	0	0	0	0	**2**
Danger's Hoek	Leribe	**M**	0.80	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	0	0	**3**
Dekeni	Quthing	**M**	3.38	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**0**	0	0	0	0	**1**
Driehoek	Thaba-Tseka	**M**	1.04	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**10**	0	0	0	0	**1**
Fika-la-Tsoene	Leribe	**M**	2.29	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**3**
Fika-le-Mohloana	Quthing	**M**	8.81	3	0	0	1	1	0	0	0	0	**4**	1	2	0	0	**4**	0	0	0	0	**3**
Filane		**M**	7.43	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**1**
Fobane	Quthing	**M**	0.05	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	**1**	0	0	0	0	**1**
Fola	Qacha's Nek	**M**	4.18	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**1**
Forosemethe	Mohale's Hoek	**S**	0.04	0	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**3**	0	0	0	0	**3**
Ha Abele	Quthing	**M**	4.93	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Api	Quthing	**M**	6.14	2	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Apili	Leribe	**M**	2.81	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Arone	Quthing	**M**	2.93	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Au	Mohale's Hoek	**M**	3.31	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**3**
Ha Aujong	Maseru	**M**	2.05	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	1	1	**5**
Ha Barete	Maseru	**M**	1.45	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Bati	Thaba-Tseka	**M**	2.78	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**4**	0	0	0	0	**3**
Ha Beka	Berea	**M**	1.06	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Belebesi	Maseru	**M**	2.97	1	0	0	1	1	0	0	0	0	**2**	1	2	0	0	**5**	0	0	0	0	**2**
Ha Bereng	Mafeteng	**M**	5.66	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Bereng Aupolasi	Leribe	**M**	1.57	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Boke	Mohale's Hoek	**M**	8.61	3	0	0	0	0	0	0	1	1	**4**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Bokoro	Quthing	**M**	1.47	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Boomo	Qacha's Nek	**M**	2.88	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**4**	0	0	0	0	**0**
Ha Boranta	Leribe	**M**	1.70	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**3**
Ha Bose	Mohale's Hoek	**M**	1.26	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Botso	Quthing	**M**	0.53	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Cassamo	Mohale's Hoek	**M**	4.20	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Caswell	Thaba-Tseka	**M**	13.27	4	0	0	0	0	0	0	0	0	**4**	0	0	0	0	**1**	0	0	0	0	**3**
Ha Chaba	Mafeteng	**M**	3.03	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	1	1	**6**
Ha Chabana	Berea	**M**	0.55	1	0	0	0	0	0	0	0	0	**1**	1	2	0	0	**4**	0	0	0	0	**2**
Ha Chaka	Leribe	**M**	0.26	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**0**
Ha Chaka	Thaba-Tseka	**S**	0.32	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Chakatsa	Quthing	**M**	0.33	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Chale	Butha-Buthe	**M**	0.16	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Challa	Qacha's Nek	**M**	6.65	2	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**2**	0	0	0	0	**3**
Ha Chelane	Maseru	**M**	2.70	1	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**1**	0	0	0	0	**3**
Ha Chele	Leribe	**M**	4.21	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Chere	Thaba-Tseka	**M**	11.11	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**2**	0	0	0	0	**3**
Ha Chola	Qacha's Nek	**M**	6.27	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**4**	0	0	0	0	**2**
Ha Chopho	Mohale's Hoek	**M**	6.84	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Chopho	Leribe	**M**	2.43	1	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**4**	0	0	0	0	**2**
Ha Chopho	Mafeteng	**M**	4.43	2	0	0	0	0	0	0	1	1	**1**	0	0	1	1	**4**	0	0	0	0	**3**

Village Name	**District**	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Damanyane	Mafeteng	**M**	5.83	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Danyele	Mohale's Hoek	**M**	0.30	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**2**
Ha Dinizulu	Mokhotlong	**S**	0.69	1	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Edward	Qacha's Nek	**M**	14.16	4	0	0	0	0	0	0	0	0	**4**	0	0	1	1	**2**	0	0	0	0	**2**
Ha Elia	Mafeteng	**M**	11.02	3	0	0	0	0	0	0	1	1	**4**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Emile	Quthing	**M**	0.73	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Fako	Quthing	**M**	6.75	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	1	1	**3**
Ha Farelane	Maseru	**S**	0.20	1	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**2**	0	0	0	0	**2**
Ha Ferete	Qacha's Nek	**M**	1.76	1	0	0	1	1	0	0	1	1	**3**	0	0	1	1	**5**	0	0	0	0	**1**
Ha Foso	Maseru	**M**	2.42	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**0**
Ha Frans	Mohale's Hoek	**M**	7.92	3	0	0	1	1	0	0	1	1	**5**	0	0	0	0	**10**	0	0	1	1	**5**
Ha Fusi	Berea	**M**	2.08	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**2**
Ha George	Maseru	**M**	3.44	1	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Griffith	Mafeteng	**M**	0.71	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	0	0	**2**
Ha Halekhetheloe	Berea	**M**	0.20	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Hamorakane	Quthing	**M**	26.31	8	0	0	1	1	0	0	1	1	**10**	0	0	0	0	**0**	0	0	0	0	**2**
Ha Hielesoa	Berea	**M**	0.15	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Hlaela	Leribe	**M**	2.19	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	0	0	**0**
Ha Hlajoane	Maseru	**M**	2.75	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Hlakacha	Leribe	**M**	0.56	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Hlakane	Maseru	**M**	0.09	0	0	0	0	0	0	0	0	0	**0**	1	2	1	1	**6**	0	0	0	0	**3**
Ha Hlalele	Mafeteng	**M**	6.44	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Hlapa	Quthing	**M**	11.00	3	0	0	1	1	0	0	0	0	**4**	0	0	0	0	**2**	0	0	0	0	**3**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Hoko	Berea	**M**	0.91	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	0	0	**2**
Ha Isaaka	Butha-Buthe	**M**	1.26	1	0	0	0	0	0	0	0	0	**4**	1	2	1	1	**2**	0	0	0	0	**1**
Ha Isaaka	Mokhotlong	**M**	10.36	3	0	0	0	0	0	0	1	1	**1**	0	0	1	1	**7**	0	0	0	0	**2**
Ha Jacob	Maseru	**M**	0.42	1	0	0	1	1	0	0	0	0	**2**	0	0	1	1	**4**	0	0	0	0	**2**
Ha Jane	Quthing	**M**	1.33	1	0	0	1	1	0	0	0	0	**2**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Janefeke	Quthing	**M**	10.71	3	0	0	1	1	0	0	0	0	**4**	0	0	1	1	**5**	0	0	0	0	**1**
Ha Jeremea	Mafeteng	**M**	2.32	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**6**
Ha Jimisi	Mohale's Hoek	**M**	11.89	4	0	0	1	1	0	0	1	1	**6**	0	0	0	0	**2**	0	0	0	0	**3**
Ha Jobo	Qacha's Nek	**M**	2.14	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Jobo	Butha-Buthe	**M**	4.70	2	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Jobo	Mohale's Hoek	**M**	14.59	4	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Jobo	Leribe	**M**	2.84	1	0	0	0	0	0	0	0	0	**4**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Jobo	Mokhotlong	**M**	6.55	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**3**	0	0	0	0	**3**
Ha Jobo Lerotholi	Mohale's Hoek	**M**	2.13	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Joel	Leribe	**M**	6.05	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**3**	0	0	1	1	**2**
Ha Joel	Quthing	**M**	8.34	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**3**
Ha Joele	Mafeteng	**M**	4.93	2	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Joele	Qacha's Nek	**M**	2.04	1	0	0	1	1	0	0	1	1	**3**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Joele	Mohale's Hoek	**M**	9.48	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Joele	Maseru	**M**	3.01	1	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Jonathane	Thaba-Tseka	**M**	10.33	3	0	0	1	1	0	0	0	0	**4**	0	0	0	0	**1**	0	0	0	0	**3**
Ha Jorose	Maseru	**M**	3.19	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**4**	0	0	0	0	**1**
Ha Josefa	Maseru	**M**	2.73	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**3**	0	0	0	0	**2**
Ha Jubile	Maseru	**M**	3.50	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Kaibe	Mafeteng	**M**	2.00	1	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**4**	0	0	1	1	**3**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Kali	Leribe	**M**	1.39	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Kanono	Mokhotlong	**M**	12.26	4	0	0	1	1	0	0	0	0	**1**	3	6	0	0	**2**	0	0	0	0	**1**
Ha Kanono	Leribe	**M**	1.43	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Kanono	Berea	**M**	0.17	1	0	0	0	0	0	0	0	0	**4**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Kanono	Mohale's Hoek	**M**	11.52	4	0	0	0	0	0	0	0	0	**5**	0	0	0	0	**14**	0	0	0	0	**2**
Ha Kao	Maseru	**M**	1.46	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**0**
Ha Kaphe	Mokhotlong	**M**	1.37	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Kata	Leribe	**M**	4.27	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Katamelo	Qacha's Nek	**M**	1.23	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Katsi	Thaba-Tseka	**M**	7.69	3	0	0	1	1	0	0	0	0	**4**	0	0	0	0	**2**	0	0	1	1	**3**
Ha Katu	Mohale's Hoek	**S**	0.40	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**1**	0	0	1	1	**4**
Ha Kebakile	Berea	**M**	8.53	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Keenya	Butha-Buthe	**M**	0.27	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Kekeleng	Butha-Buthe	**M**	5.42	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Keketsi	Maseru	**M**	0.34	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Kelebone	Qacha's Nek	**M**	3.48	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**3**	0	0	0	0	**0**
Ha Kelebone	Leribe	**M**	8.33	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Kena	Mohale's Hoek	**M**	0.93	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**3**
Ha Kenna	Mafeteng	**M**	0.14	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**8**	0	0	0	0	**1**
Ha Khabisi	Quthing	**S**	0.42	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Khajoane	Maseru	**M**	2.88	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**4**	0	0	1	1	**3**
Ha Khakhau	Thaba-Tseka	**M**	0.07	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	**1**	0	0	0	0	**4**
Ha Khama	Maseru	**S**	0.12	1	0	0	1	1	0	0	1	1	**5**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Khama	Mohale's Hoek	**M**	14.27	4	0	0	1	1	0	0	0	0	**4**	0	0	0	0	**5**	0	0	0	0	**1**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Khamakhamane	Quthing	**M**	0.11	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	0	0	**1**
Ha Khanyetsi	Mokhotlong	**M**	17.47	5	0	0	0	0	0	0	0	0	**5**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Khate	Maseru	**M**	3.26	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	0	0	**1**
Ha Khatleli	Mohale's Hoek	**M**	7.93	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Khauta	Maseru	**S**	0.49	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**2**	0	0	0	0	**1**
Ha K'Henene	Mohale's Hoek	**M**	13.59	4	0	0	0	0	0	0	1	1	**5**	0	0	0	0	**4**	0	0	0	0	**2**
Ha Khethisa	Mokhotlong	**M**	0.29	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Khoai	Leribe	**M**	2.83	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Khoaisanyane	Thaba-Tseka	**M**	14.34	4	0	0	0	0	0	0	0	0	**4**	0	0	0	0	**2**	0	0	0	0	**5**
Ha Khoali	Quthing	**M**	4.53	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Khoalinyane	Mohale's Hoek	**M**	0.08	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	**1**	0	0	0	0	**3**
Ha Khoalipane	Thaba-Tseka	**M**	6.34	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	1	1	**5**
Ha Khoanyane	Thaba-Tseka	**M**	4.70	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Khoarai	Mohale's Hoek	**M**	2.27	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Khoarai	Qacha's Nek	**M**	0.38	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Khoeli	Thaba-Tseka	**M**	0.21	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Khohlooa	Berea	**M**	4.30	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Khohlopo	Maseru	**M**	2.10	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Khojane	Maseru	**M**	0.12	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Khojane	Berea	**M**	1.47	1	0	0	0	0	0	0	0	0	**4**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Khojane	Thaba-Tseka	**M**	8.22	3	0	0	0	0	0	0	1	1	**1**	0	0	0	0	**5**	0	0	0	0	**1**
Ha Khola	Maseru	**M**	1.86	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Kholoane	Mafeteng	**M**	14.40	4	0	0	3	3	0	0	0	0	**7**	0	0	0	0	**2**	0	0	0	0	**5**
Ha Kholoanyane	Leribe	**M**	0.44	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Kholoko	Mafeteng	**M**	2.95	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	1	1	**3**
Ha Kholooa	Mohale's Hoek	**M**	1.44	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Khopa	Mafeteng	**M**	2.25	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**2**	0	0	1	1	**3**
Ha Khotseng	Maseru	**M**	3.82	2	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**1**	0	0	0	0	**0**
Ha Khumamang	Quthing	**M**	2.10	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Khupiso	Leribe	**M**	2.08	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**3**
Ha Koasa	Maseru	**M**	0.31	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Kobeli	Quthing	**M**	8.50	3	0	0	1	1	0	0	0	0	**4**	0	0	0	0	**2**	0	0	0	0	**0**
Ha Kobo-Tsoeu	Thaba-Tseka	**M**	2.26	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Koeneho	Leribe	**M**	0.55	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Koenyama	Maseru	**M**	0.80	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**4**
Ha Koili	Mohale's Hoek	**M**	0.93	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**3**
Ha Kooko	Mokhotlong	**M**	1.04	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**3**
Ha Koone	Maseru	**M**	2.42	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Koporale	Thaba-Tseka	**M**	7.45	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**3**	0	0	0	0	**2**
Ha Koranta	Quthing	**M**	4.09	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Kori	Berea	**M**	3.54	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Korotsoane	Thaba-Tseka	**M**	5.40	2	0	0	3	3	0	0	1	1	**6**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Kosteabole	Mafeteng	**M**	1.36	1	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**2**	0	0	0	0	**5**
Ha Kotoane	Maseru	**M**	3.59	1	0	0	1	1	0	0	3	3	**5**	0	0	0	0	**1**	0	0	0	0	**1**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Kotoanyane	Berea	**M**	0.22	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**3**
Ha Kotsana	Leribe	**M**	4.67	2	1	1	3	3	0	0	0	0	**6**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Kotsoana	Thaba-Tseka	**S**	0.18	1	0	0	2	2	0	0	2	2	**6**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Kotsoane 'Melikane	Mafeteng	**M**	3.54	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Kubutu	Leribe	**M**	2.06	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Kubutu	Mohale's Hoek	**M**	7.30	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**3**
Ha Kuili	Qacha's Nek	**M**	7.49	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Kujoana	Maseru	**M**	4.24	2	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**5**	0	0	1	1	**6**
Ha Kutumane	Mafeteng	**M**	2.30	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Labane	Mafeteng	**M**	1.72	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Laene	Mohale's Hoek	**M**	8.35	3	0	0	0	0	0	0	1	1	**4**	0	0	0	0	**3**	0	0	0	0	**2**
Ha Lali	Maseru	**M**	1.75	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**4**
Ha Lazaro	Thaba-Tseka	**M**	0.93	1	0	0	1	1	0	0	0	0	**2**	1	2	0	0	**5**	0	0	0	0	**5**
Ha Leaoa	Mohale's Hoek	**M**	10.61	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**4**	0	0	0	0	**1**
Ha Lebala	Thaba-Tseka	**M**	1.66	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Lebamang	Quthing	**M**	7.95	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Lebe....	Leribe	**M**	2.50	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	1	1	**3**
Ha Lebelo	Thaba-Tseka	**M**	7.18	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**3**	0	0	0	0	**5**
Ha Lebenkele	Maseru	**M**	0.17	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**4**
Ha Lebesa	Mafeteng	**M**	1.05	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Lebiletsa	Maseru	**M**	5.68	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	1	1	**7**
Ha Lebina	Mafeteng	**M**	0.30	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**2**
Ha Leboea	Butha-Buthe	**M**	0.99	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**2**
Ha Lebokose	Maseru	**M**	2.91	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**1**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Lebona	Berea	**M**	3.64	1	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**1**	0	0	1	1	**1**
Ha Lebona	Leribe	**M**	7.87	3	0	0	0	0	0	0	0	0	**5**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Lebona	Maseru	**S**	0.29	1	0	0	2	2	0	0	1	1	**1**	0	0	0	0	**3**	0	0	0	0	**3**
Ha Lebopo	Quthing	**M**	6.62	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Leboto	Thaba-Tseka	**M**	2.92	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Lecheche	Maseru	**S**	0.24	1	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Lechesa	Mokhotlong	**M**	4.19	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**5**	0	0	0	0	**1**
Ha Lechesa	Mafeteng	**M**	2.96	1	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**7**	0	0	0	0	**1**
Ha Lechesa	Mohale's Hoek	**M**	4.87	2	0	0	0	0	0	0	1	1	**2**	0	0	1	1	**1**	0	0	0	0	**4**
Ha Leeba	Mokhotlong	**S**	0.27	1	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**3**	0	0	0	0	**2**
Ha Leferefere	Maseru	**M**	17.33	5	0	0	1	1	0	0	0	0	**6**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Lehlohonolo	Mohale's Hoek	**M**	11.20	3	0	0	0	0	0	0	1	1	**4**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Lehlohonolo	Mohale's Hoek	**M**	4.74	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Lejaha	Mokhotlong	**M**	1.57	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Leketa	Mokhotlong	**M**	1.48	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**5**	0	0	0	0	**1**
Ha Lekhetho	Berea	**M**	0.10	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Lekhoba	Berea	**M**	4.86	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Lekula	Mohale's Hoek	**M**	3.79	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**5**
Ha Lelaka	Maseru	**M**	3.70	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Lelingoana	Quthing	**M**	0.17	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Lelingoana	Butha-Buthe	**M**	0.39	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**7**	0	0	0	0	**1**
Ha Lempe	Thaba-Tseka	**M**	2.81	1	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Lempe	Qacha's Nek	**M**	8.60	3	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**5**	0	0	0	0	**1**
Ha Lempetje	Leribe	**M**	22.89	7	0	0	1	1	0	0	0	0	**8**	0	0	1	1	**6**	0	0	0	0	**1**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Lemphane	Mohale's Hoek	**M**	13.20	4	0	0	3	3	0	0	0	0	**7**	0	0	1	1	**6**	0	0	0	0	**0**
Ha Lengau	Maseru	**S**	0.31	1	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**4**	0	0	1	1	**6**
Ha Lenka	Mafeteng	**M**	0.74	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Lenkoane	Butha-Buthe	**M**	14.77	4	0	0	1	1	0	0	0	0	**5**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Lenonyane	Mohale's Hoek	**M**	4.46	2	0	0	1	1	0	0	0	0	**3**	0	0	1	1	**4**	0	0	0	0	**0**
Ha Lentiti	Mohale's Hoek	**M**	4.13	2	0	0	1	1	0	0	2	2	**5**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Leoka	Berea	**M**	8.45	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**2**	0	0	0	0	**2**
Ha Lepatoa	Mafeteng	**M**	0.34	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	1	1	**7**
Ha Lepekola	Maseru	**M**	2.59	1	0	0	0	0	0	0	1	1	**0**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Lepekola	Thaba-Tseka	**M**	0.07	0	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Lephako	Butha-Buthe	**M**	0.10	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Lephatsoane	Mohale's Hoek	**M**	1.57	1	0	0	2	2	0	0	0	0	**3**	0	0	0	0	**4**	0	0	0	0	**1**
Ha Lephoi	Butha-Buthe	**M**	6.96	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Lepholisa	Maseru	**M**	3.81	2	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Lephoto	Butha-Buthe	**M**	13.34	4	0	0	1	1	0	0	1	1	**6**	0	0	0	0	**4**	0	0	0	0	**1**
Ha Lepolesa	Berea	**M**	2.98	1	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Lepolesa	Leribe	**M**	10.60	3	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Leronti	Mohale's Hoek	**M**	7.68	3	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Leronti	Mafeteng	**M**	0.40	1	0	0	0	0	0	0	0	0	**4**	0	0	0	0	**11**	0	0	0	0	**1**
Ha Leronti	Berea	**M**	10.28	3	0	0	0	0	0	0	1	1	**3**	0	0	1	1	**1**	0	0	0	0	**2**
Ha Lerumonyane	Mohale's Hoek	**M**	0.42	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Leruo	Maseru	**S**	0.53	1	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Lesala	Thaba-Tseka	**M**	5.24	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**4**	0	0	0	0	**2**
Ha Lesaoana	Maseru	**M**	4.40	2	0	0	1	1	0	0	0	0	**3**	0	0	1	1	**2**	0	0	0	0	**1**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Lesaoana	Thaba-Tseka	**M**	4.19	2	0	0	0	0	0	0	0	0	**2**	0	0	2	2	**3**	0	0	0	0	**1**
Ha Leshoele	Maseru	**S**	0.39	1	0	0	0	0	0	0	1	1	**3**	0	0	1	1	**2**	0	0	0	0	**2**
Ha Leshota	Butha-Buthe	**M**	1.77	1	0	0	1	1	0	0	0	0	**2**	0	0	1	1	**7**	0	0	0	0	**3**
Ha Lesoiti	Mafeteng	**M**	2.34	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Lesole	Leribe	**M**	1.69	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Lesoli	Mokhotlong	**M**	16.77	5	0	0	0	0	0	0	1	1	**6**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Lesoma	Maseru	**M**	1.93	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	1	1	**4**
Ha Leta	Mafeteng	**M**	1.46	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	0	0	**3**
Ha Leteketa	Maseru	**M**	3.50	1	0	0	0	0	0	0	1	1	**2**	0	0	2	2	**4**	0	0	0	0	**1**
Ha Letele	Mafeteng	**S**	0.48	1	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**7**	0	0	0	0	**1**
Ha Letete	Thaba-Tseka	**M**	1.19	1	0	0	0	0	0	0	0	0	**1**	0	0	2	2	**9**	0	0	0	0	**3**
Ha Lethane	Mafeteng	**M**	1.55	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	0	0	**8**
Ha Lethena	Maseru	**M**	14.57	4	0	0	3	3	0	0	0	0	**5**	0	0	1	1	**8**	0	0	0	0	**1**
Ha Lethena	Qacha's Nek	**M**	13.22	4	0	0	1	1	0	0	0	0	**7**	0	0	4	4	**3**	0	0	0	0	**3**
Ha Lethokonyane	Maseru	**M**	1.78	1	0	0	1	1	0	0	1	1	**3**	0	0	1	1	**2**	0	0	0	0	**2**
Ha Letjama (Ha Matooane)	Mohale's Hoek	**S**	0.25	1	0	0	0	0	0	0	1	1	**3**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Letseka	Quthing	**M**	8.18	3	0	0	0	0	0	0	0	0	**3**	0	0	3	3	**5**	0	0	0	0	**1**
Ha Letsema	Berea	**M**	3.13	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Letsie	Mokhotlong	**M**	4.00	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**3**	0	0	1	1	**2**
Ha Letsie	Leribe	**M**	5.70	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**12**	0	0	0	0	**4**
Ha Letsika	Mafeteng	**S**	0.87	1	0	0	0	0	0	0	1	1	**3**	0	0	2	2	**3**	0	0	0	0	**1**
Ha Letsipa	Berea	**M**	9.65	3	0	0	1	1	0	0	0	0	**4**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Letsoara	Maseru	**M**	0.62	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	1	1	**3**
Ha Letsoela	Thaba-Tseka	**M**	0.08	0	0	0	0	0	0	0	0	0	**0**	0	0	1	1	**4**	0	0	0	0	**1**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Letsooa	Berea	**M**	0.51	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Leu	Mafeteng	**M**	4.50	2	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Leutsoa	Berea	**M**	9.17	3	0	0	2	2	0	0	0	0	**5**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Libe	Qacha's Nek	**S**	0.83	1	0	0	1	1	0	0	1	1	**2**	0	0	1	1	**1**	0	0	0	0	**1**
Ha Libe	Maseru	**M**	3.02	1	0	0	1	1	0	0	0	0	**2**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Libe	Maseru	**M**	0.89	1	0	0	1	1	0	0	0	0	**4**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Libenyana	Thaba-Tseka	**M**	5.19	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**3**	0	0	1	1	**4**
Ha Libete	Mohale's Hoek	**M**	6.90	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**8**	0	0	0	0	**1**
Ha Lieta	Leribe	**M**	1.25	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**5**	0	0	0	0	**1**
Ha Likomisi	Thaba-Tseka	**M**	7.24	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**3**	0	0	0	0	**3**
Ha Likupa	Thaba-Tseka	**M**	20.47	6	0	0	1	1	0	0	0	0	**7**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Lipala	Berea	**M**	7.86	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**3**	0	0	0	0	**3**
Ha Liphapang	Maseru	**M**	6.59	2	0	0	1	1	0	0	0	0	**3**	0	0	1	1	**6**	0	0	0	0	**3**
Ha Liphate	Mafeteng	**M**	0.63	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**2**
Ha Liphoto	Mohale's Hoek	**M**	2.92	1	0	0	0	0	0	0	1	1	**2**	0	0	1	1	**2**	0	0	1	1	**6**
Ha Lireng	Quthing	**M**	17.16	5	0	0	1	1	0	0	0	0	**6**	0	0	1	1	**9**	0	0	0	0	**1**
Ha Lishobana	Mokhotlong	**M**	5.52	2	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**2**	0	0	0	0	**2**
Ha Litathane	Berea	**M**	2.43	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	0	0	**5**
Ha Lumisi	Mokhotlong	**M**	24.31	7	0	0	0	0	0	0	0	0	**7**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Maanela	Butha-Buthe	**M**	2.81	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Maarna	Maseru	**M**	1.20	1	0	0	0	0	0	0	1	1	**2**	0	0	1	1	**2**	0	0	0	0	**2**
Ha Mabaka	Mafeteng	**M**	0.46	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**3**
Ha 'Mabatho	Thaba-Tseka	**M**	8.07	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**6**	0	0	0	0	**1**
Ha Mabatla	Maseru	**M**	2.91	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Mabekenyane	Mohale's Hoek	**S**	0.33	1	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**4**	0	0	0	0	**2**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha 'Mabernice	Mohale's Hoek	**M**	4.42	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**3**
Ha Mabina	Mafeteng	**M**	5.87	2	0	0	1	1	0	0	0	0	**3**	0	0	1	1	**2**	0	0	1	1	**5**
Ha Machakela	Berea	**M**	0.59	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Machakela	Maseru	**M**	0.34	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Machakela	Quthing	**M**	3.63	1	0	0	0	0	0	0	1	1	**2**	0	0	1	1	**4**	0	0	0	0	**2**
Ha Machesetsa	Mafeteng	**M**	3.09	1	0	0	1	1	0	0	1	1	**3**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Maepho	Mafeteng	**M**	1.06	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**4**	0	0	0	0	**2**
Ha Maetsela	Quthing	**M**	8.88	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Mafamolane	Quthing	**M**	3.31	1	0	0	0	0	0	0	1	1	**2**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Mafethe	Maseru	**M**	10.68	3	0	0	0	0	0	0	1	1	**4**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Mafura	Berea	**M**	2.86	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**4**
Ha Mahabe	Berea	**M**	5.26	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Mahao	Mohale's Hoek	**M**	1.03	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	1	1	**3**
Ha Mahlahlathane	Quthing	**M**	4.01	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Mahlasane	Qacha's Nek	**M**	2.05	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**3**
Ha Mahlatsi	Thaba-Tseka	**M**	9.52	3	0	0	1	1	0	0	0	0	**4**	0	0	0	0	**4**	0	0	0	0	**1**
Ha Mahlehle	Mafeteng	**M**	1.32	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Mahleke	Mafeteng	**M**	3.12	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**2**
Ha Mahlekefane	Thaba-Tseka	**M**	14.35	4	0	0	0	0	0	0	0	0	**4**	0	0	0	0	**2**	0	0	0	0	**3**
Ha Mahlelebo	Leribe	**M**	3.23	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Mahloana	Berea	**M**	2.98	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**

Village Name	**District**	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Mahlokohloko	Butha-Buthe	**M**	5.81	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**7**	0	0	0	0	**2**
Ha Mahlomola	Maseru	**S**	0.38	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**1**	0	0	0	0	**3**
Ha Mahlong	Leribe	**M**	0.67	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	1	1	**4**
Ha Maholi	Thaba-Tseka	**M**	20.48	6	0	0	0	0	0	0	1	1	**7**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Maholi	Leribe	**S**	0.16	1	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**2**	0	0	1	1	**5**
Ha Maieane	Thaba-Tseka	**M**	1.26	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**3**
Ha Maime	Mafeteng	**M**	1.81	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**7**	0	0	0	0	**2**
Ha Maisa	Mafeteng	**M**	0.40	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	1	1	**3**
Ha 'Majane	Leribe	**M**	3.32	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**5**	0	0	0	0	**1**
Ha Majara	Berea	**M**	20.01	6	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Majara	Quthing	**M**	11.10	3	0	0	1	1	0	0	0	0	**1**	0	0	0	0	**5**	0	0	0	0	**1**
Ha Majara	Maseru	**S**	0.29	1	0	0	0	0	0	0	1	1	**4**	0	0	1	1	**1**	0	0	0	0	**2**
Ha Majara	Leribe	**M**	0.65	1	0	0	0	0	0	0	0	0	**6**	0	0	1	1	**3**	0	0	0	0	**2**
Ha Majoro	Thaba-Tseka	**M**	3.48	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	1	1	**3**
Ha Makae	Butha-Buthe	**M**	2.14	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Makafana	Quthing	**M**	6.10	2	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**2**	0	0	1	1	**4**
Ha 'Makaliso	Berea	**M**	5.64	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**5**	0	0	0	0	**3**
Ha Makama	Maseru	**M**	2.76	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Makara	Maseru	**M**	1.20	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**6**	0	0	1	1	**3**
Ha Makebe	Berea	**M**	8.93	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Makefane	Quthing	**M**	5.15	2	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**9**	0	0	0	0	**5**
Ha Makeleme	Thaba-Tseka	**M**	11.56	4	0	0	1	1	0	0	0	0	**5**	0	0	0	0	**4**	0	0	1	1	**4**
Ha Makena	Berea	**S**	0.03	0	0	0	2	2	0	0	2	2	**5**	0	0	0	0	**2**	0	0	0	0	**4**
Ha Makepe	Mokhotlong	**M**	20.86	6	2	2	3	3	0	0	0	0	**11**	0	0	0	0	**2**	0	0	0	0	**2**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Makhabane	Thaba-Tseka	**M**	13.51	4	0	0	0	0	0	0	1	1	**5**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Makhabane	Leribe	**M**	3.50	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**4**
Ha Makhakesta	Mohale's Hoek	**M**	7.49	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Makhakhe	Mokhotlong	**M**	8.84	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Makhala	Mohale's Hoek	**M**	0.17	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Makhalanyane	Leribe	**M**	6.10	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**3**	0	0	0	0	**2**
Ha Makhata	Mohale's Hoek	**M**	4.67	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Makhate	Thaba-Tseka	**M**	5.78	2	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Makhathe	Maseru	**M**	0.35	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Makhetha	Leribe	**M**	0.21	1	0	0	0	0	0	0	0	0	**1**	1	2	0	0	**6**	0	0	0	0	**2**
Ha Makhethe	Mohale's Hoek	**M**	0.24	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Makhina	Mafeteng	**M**	3.59	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Makhoa	Mohale's Hoek	**M**	12.02	4	0	0	0	0	0	0	1	1	**5**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Makhobalo	Butha-Buthe	**M**	5.05	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**2**
Ha 'Makhoshane	Thaba-Tseka	**M**	8.14	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**1**
Ha 'Makhotso	Leribe	**M**	0.40	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	0	0	**3**
Ha Makhube	Berea	**M**	3.62	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Makhula	Butha-Buthe	**M**	3.70	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Makintane	Thaba-Tseka	**M**	13.40	4	0	0	0	0	0	0	0	0	**4**	0	0	0	0	**1**	0	0	0	0	**1**
Ha 'Mako	Mohale's Hoek	**M**	1.63	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha 'Mako	Berea	**M**	6.14	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**1**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Makoae	Mafeteng	**M**	0.29	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Makoae	Leribe	**M**	2.65	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	0	0	**1**
Ha 'Makoaela	Maseru	**M**	3.17	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Makoanyane	Mohale's Hoek	**M**	11.98	4	0	0	1	1	0	0	2	2	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Makoanyane	Quthing	**M**	0.79	1	0	0	0	0	0	0	0	0	**7**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Makoaqa	Berea	**S**	0.38	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Makoetlane	Leribe	**M**	1.25	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Makoko	Mohale's Hoek	**M**	2.67	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Makoloane	Mafeteng	**M**	1.85	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Makopela	Mohale's Hoek	**M**	4.55	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**3**	0	0	0	0	**2**
Ha Makotoko	Thaba-Tseka	**M**	0.39	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	1	1	**5**
Ha Makuini	Quthing	**M**	0.80	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**3**
Ha Makuka	Mafeteng	**M**	3.87	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**5**	0	0	0	0	**2**
Ha Malane	Maseru	**M**	4.02	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**3**	0	0	0	0	**3**
Ha Malapane	Butha-Buthe	**M**	1.48	1	0	0	0	0	0	0	0	0	**1**	2	4	0	0	**9**	0	0	0	0	**2**
Ha Malebanye	Leribe	**M**	1.69	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**1**
Ha 'Maleemisa	Mohale's Hoek	**M**	11.07	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**4**	0	0	0	0	**2**
Ha Malefane	Mokhotlong	**M**	12.01	4	0	0	0	0	0	0	1	1	**5**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Malephane	Mohale's Hoek	**M**	2.86	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Malephane	Mohale's Hoek	**M**	13.66	4	0	0	0	0	0	0	1	1	**5**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Malesaoana	Leribe	**M**	0.48	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	1	1	**7**
Ha' Mali	Quthing	**M**	0.19	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**1**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Malibe	Mohale's Hoek	**M**	5.38	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**2**	0	0	0	0	**1**
Ha 'Maliepetsane	Leribe	**M**	0.74	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Malimabe	Leribe	**M**	0.35	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Malinyane	Quthing	**M**	1.87	1	0	0	0	0	0	0	0	0	**1**	1	2	0	0	**9**	0	0	0	0	**5**
Ha Maloto	Mafeteng	**M**	1.65	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Maluke	Berea	**M**	3.88	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**3**	0	0	1	1	**2**
Ha 'Mamafofo	Mokhotlong	**M**	24.06	7	0	0	0	0	0	0	1	1	**8**	0	0	0	0	**1**	0	0	0	0	**1**
Ha 'Mamanka	Butha-Buthe	**M**	0.62	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**4**
Ha 'Mamatebele	Mohale's Hoek	**M**	9.95	3	0	0	0	0	0	0	1	1	**4**	0	0	0	0	**1**	0	0	1	1	**3**
Ha Manama	Leribe	**M**	1.80	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Manamoleta	Leribe	**M**	2.27	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**0**
Ha Manehella	Berea	**M**	3.52	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**0**
Ha Mangana	Maseru	**M**	2.50	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Manganane	Leribe	**M**	8.95	3	0	0	0	0	0	0	1	1	**4**	0	0	0	0	**3**	0	0	0	0	**1**
Ha 'Mankata	Mafeteng	**M**	4.96	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**5**	0	0	0	0	**0**
Ha 'Mankopane	Berea	**M**	7.45	2	0	0	0	0	0	0	3	3	**5**	0	0	0	0	**2**	0	0	1	1	**3**
Ha 'Manteko	Mohale's Hoek	**M**	4.28	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Mantheki	Quthing	**M**	12.46	4	0	0	1	1	0	0	1	1	**6**	0	0	0	0	**3**	0	0	0	0	**1**
Ha 'Mantlobo	Mokhotlong	**M**	7.47	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Mantsi	Qacha's Nek	**M**	0.20	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha 'Mantsieng	Berea	**M**	9.24	3	0	0	1	1	0	0	0	0	**4**	0	0	0	0	**2**	0	0	1	1	**5**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Manyakane	Butha-Buthe	**M**	1.64	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**5**	0	0	0	0	**2**
Ha Manyatse	Thaba-Tseka	**M**	1.39	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Maoela	Mokhotlong	**M**	4.22	2	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Maonyane	Mokhotlong	**M**	11.09	3	1	1	1	1	0	0	1	1	**6**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Maope	Qacha's Nek	**M**	0.64	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha 'Mapa	Mafeteng	**M**	5.40	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Mapena	Maseru	**M**	2.81	1	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**4**	0	0	0	0	**1**
Ha Mapetla	Berea	**M**	0.77	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Maphelle	Berea	**M**	2.34	1	0	0	0	0	0	0	0	0	**1**	1	2	0	0	**5**	0	0	0	0	**1**
Ha Maphohloane	Quthing	**M**	9.35	3	0	0	1	1	0	0	1	1	**5**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Mapholo	Maseru	**M**	1.82	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Maphoma	Thaba-Tseka	**M**	10.32	3	0	0	1	1	0	0	1	1	**5**	0	0	0	0	**1**	0	0	1	1	**4**
Ha Mapitsi	Mohale's Hoek	**M**	0.37	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**0**	0	0	0	0	**1**
Ha Mapoho	Maseru	**M**	0.16	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**0**
Ha Maqeba	Maseru	**M**	1.61	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Maqele	Maseru	**S**	0.09	0	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Marakabei	Maseru	**M**	3.91	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Marana	Mohale's Hoek	**M**	6.25	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**3**	0	0	0	0	**2**
Ha Mariti	Leribe	**M**	1.07	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Maruping	Butha-Buthe	**M**	0.33	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Masakale	Leribe	**M**	9.84	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Masea	Thaba-Tseka	**M**	5.44	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**5**	0	0	1	1	**5**
Ha 'Masefabatho	Quthing	**M**	2.25	1	0	0	0	0	0	0	1	1	**2**	0	0	1	1	**4**	0	0	0	0	**1**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Maseru	Maseru	**M**	3.53	1	0	0	1	1	0	0	0	0	**2**	0	0	1	1	**3**	0	0	0	0	**2**
Ha Mashapha	Quthing	**M**	13.19	4	0	0	1	1	0	0	0	0	**5**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Mashapha	Mohale's Hoek	**M**	9.49	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Mashapha	Maseru	**M**	3.76	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**3**	0	0	0	0	**2**
Ha Mashenephe	Quthing	**M**	2.03	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**9**
Ha Masilo	Mafeteng	**M**	4.65	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Masiphane	Leribe	**M**	8.28	3	0	0	0	0	0	0	1	1	**4**	0	0	1	1	**5**	0	0	1	1	**6**
Ha Masireletse	Maseru	**M**	1.04	1	0	0	0	0	0	0	1	1	**2**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Masita	Maseru	**M**	0.35	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Masitise	Berea	**M**	7.64	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Masiu	Maseru	**M**	1.32	1	0	0	1	1	0	0	1	1	**3**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Masiu	Mohale's Hoek	**M**	6.44	2	0	0	1	1	0	0	0	0	**3**	0	0	1	1	**5**	0	0	0	0	**1**
Ha Masta	Quthing	**M**	10.23	3	0	0	1	1	0	0	0	0	**4**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Masunhloane	Mafeteng	**M**	1.37	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Masupha	Quthing	**M**	5.00	2	0	0	0	0	0	0	1	1	**3**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Matala	Berea	**M**	8.24	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Matebesi	Mohale's Hoek	**M**	0.55	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Matekane	Quthing	**M**	3.55	1	0	0	1	1	0	0	1	1	**3**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Matekane	Leribe	**M**	4.21	2	0	0	0	0	0	0	1	1	**3**	0	0	1	1	**5**	0	0	0	0	**1**
Ha Matela	Mohale's Hoek	**M**	3.71	1	0	0	0	0	0	0	1	1	**2**	0	0	2	2	**3**	0	0	0	0	**1**
Ha Matete	Berea	**M**	2.88	1	0	0	0	0	0	0	0	0	**4**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Matete	Mohale's Hoek	**M**	14.57	4	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**5**	0	0	0	0	**1**
Ha Matetoane	Maseru	**M**	2.33	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**10**	0	0	0	0	**1**

Village Name	**District**	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Mateu	Leribe	**M**	14.18	4	0	0	0	0	0	0	1	1	**5**	0	0	1	1	**3**	0	0	0	0	**1**
Ha 'Mathabang	Maseru	**M**	0.75	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**2**
Ha Mathatela	Mafeteng	**M**	3.33	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Mathe	Thaba-Tseka	**S**	0.38	1	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**4**	0	0	0	0	**1**
Ha Mathibeli	Mafeteng	**M**	2.89	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Matholoana	Thaba-Tseka	**M**	5.53	2	0	0	1	1	0	0	0	0	**3**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Matjota	Quthing	**M**	12.49	4	0	0	0	0	0	0	0	0	**4**	0	0	1	1	**4**	0	0	0	0	**1**
Ha 'Matjotjo	Mokhotlong	**M**	2.28	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Matlali	Berea	**M**	2.11	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Matlali	Mokhotlong	**S**	0.73	1	0	0	0	0	0	0	1	1	**3**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Matobo	Berea	**M**	0.70	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Matoli	Qacha's Nek	**M**	2.33	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Matona	Mafeteng	**M**	0.42	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha 'Matsa	Mokhotlong	**M**	6.86	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**1**
Ha 'Matsa	Leribe	**M**	0.86	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	0	0	**2**
Ha Matsaba	Leribe	**M**	5.47	2	0	0	0	0	0	0	0	0	**2**	0	0	3	3	**5**	0	0	0	0	**1**
Ha Matseka	Mafeteng	**M**	2.21	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Matseo	Mohale's Hoek	**M**	14.27	4	0	0	0	0	0	0	1	1	**5**	0	0	0	0	**3**	0	0	0	0	**2**
Ha Matsie	Mafeteng	**M**	0.60	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Matsoele	Qacha's Nek	**M**	3.05	1	0	0	0	0	0	0	1	1	**2**	0	0	1	1	**6**	0	0	0	0	**1**
Ha Matsoete	Mohale's Hoek	**M**	6.61	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Matsoso	Mafeteng	**M**	2.61	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Matsumunyane	Leribe	**M**	11.87	4	1	1	6	6	0	0	0	0	**11**	0	0	0	0	**3**	0	0	1	1	**4**

Village Name	**District**	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha 'Matumo	Leribe	**M**	2.09	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Mei	Berea	**M**	8.07	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Meno	Thaba-Tseka	**M**	6.77	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**4**	0	0	0	0	**1**
Ha Mensel	Berea	**M**	0.99	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**0**
Ha Meshaka	Mokhotlong	**M**	0.46	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**0**
Ha 'Meta	Mokhotlong	**M**	14.21	4	0	0	0	0	0	0	1	1	**1**	0	0	0	0	**1**	0	0	0	0	**2**
Ha 'Meta	Thaba-Tseka	**M**	0.60	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**2**
Ha 'Meta	Maseru	**M**	2.64	1	0	0	0	0	0	0	0	0	**5**	0	0	0	0	**4**	0	0	0	0	**2**
Ha 'Mika	Mokhotlong	**M**	11.90	4	0	0	0	0	0	0	1	1	**5**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Moahloli	Mohale's Hoek	**M**	3.87	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Moalosi	Mohale's Hoek	**M**	1.53	1	0	0	1	1	0	0	0	0	**2**	0	0	1	1	**2**	0	0	0	0	**2**
Ha Moeketsane	Leribe	**M**	2.10	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	1	1	**3**
Ha Moeletsi	Maseru	**M**	0.48	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**0**	0	0	0	0	**1**
Ha Moeletsi	Qacha's Nek	**M**	2.57	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Moeti	Mokhotlong	**M**	7.54	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Moetsuoa	Mohale's Hoek	**M**	2.62	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	0	0	**2**
Ha Mofoka	Mafeteng	**M**	0.08	0	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**0**	0	0	0	0	**1**
Ha Mofoka	Maseru	**M**	2.33	1	0	0	0	0	0	0	0	0	**0**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Mofoqoi	Butha-Buthe	**M**	14.96	4	0	0	1	1	0	0	0	0	**5**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Mofota	Maseru	**M**	0.45	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Mofu	Mafeteng	**M**	0.07	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Mofubetsoana	Maseru	**S**	0.48	1	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**3**	0	0	0	0	**2**
Ha Mofutisi	Mafeteng	**M**	7.10	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**3**	0	0	0	0	**2**
Ha Mohale	Mohale's Hoek	**S**	0.16	1	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**5**	0	0	0	0	**1**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Mohale	Maseru	**M**	4.73	2	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**1**	0	0	0	0	**3**
Ha Mohalenya	Maseru	**M**	2.24	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Mohapeloa	Mokhotlong	**M**	12.70	4	0	0	1	1	0	0	0	0	**5**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Mohate	Mohale's Hoek	**M**	2.30	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**5**	0	0	0	0	**1**
Ha Mohatlane	Butha-Buthe	**M**	0.86	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Mohau	Mohale's Hoek	**M**	0.09	0	0	0	0	0	0	0	0	0	**5**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Mohau	Mohale's Hoek	**M**	12.06	4	0	0	0	0	0	0	1	1	**0**	0	0	0	0	**6**	0	0	0	0	**1**
Ha Mohlabakabo	Berea	**M**	0.43	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Mohlakoana	Thaba-Tseka	**M**	1.68	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**2**
Ha Mohlapiso	Butha-Buthe	**M**	2.74	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	0	0	**2**
Ha Mohlehi	Mokhotlong	**M**	0.54	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	0	0	**2**
Ha Mohlokaqala	Quthing	**S**	0.32	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Mohohlo	Qacha's Nek	**M**	3.19	1	0	0	0	0	0	0	1	1	**2**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Moholi	Mafeteng	**M**	4.87	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Moiketsi	Leribe	**M**	4.40	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Moiloa	Mohale's Hoek	**M**	5.80	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Moitsupeli	Quthing	**M**	1.26	1	0	0	1	1	0	0	1	1	**3**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Mojaki	Mohale's Hoek	**M**	5.06	2	0	0	0	0	0	0	1	1	**3**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Mojakisare		**M**	6.82	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**3**	0	0	0	0	**2**
Ha Mojapele	Maseru	**S**	0.39	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**3**	0	0	0	0	**2**
Ha Mojela	Qacha's Nek	**M**	0.67	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**0**
Ha Mojela	Mokhotlong	**M**	0.13	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Mokae	Leribe	**M**	8.82	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**2**	0	0	0	0	**3**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Mokalimotso	Maseru	**S**	0.53	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Mokati	Berea	**M**	1.23	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Mokati	Quthing	**M**	5.56	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Mokhachane	Mohale's Hoek	**M**	1.30	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Mokhachane	Leribe	**M**	3.29	1	0	0	2	2	0	0	0	0	**3**	0	0	1	1	**4**	0	0	0	0	**2**
Ha Mokhameleli	Leribe	**M**	1.83	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Mokhasi	Berea	**M**	3.54	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Mokhathi	Leribe	**M**	5.20	2	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Mokhathi	Berea	**M**	8.49	3	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**4**	0	0	0	0	**2**
Ha Mokhatla	Mafeteng	**M**	5.63	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Mokhehle	Maseru	**S**	0.34	1	0	0	0	0	0	0	3	3	**5**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Mokhele	Berea	**M**	7.61	3	0	0	3	3	0	0	0	0	**6**	0	0	1	1	**2**	0	0	0	0	**2**
Ha Mokheseng	Mohale's Hoek	**M**	1.87	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Mokhesi	Berea	**M**	0.21	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Mokhethi	Mohale's Hoek	**M**	2.74	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Mokhethoane	Maseru	**M**	2.03	1	0	0	1	1	0	0	1	1	**3**	1	2	0	0	**4**	0	0	0	0	**3**
Ha Mokhoaetsi	Leribe	**M**	5.76	2	1	1	3	3	0	0	0	0	**6**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Mokhoro	Berea	**M**	9.34	3	0	0	0	0	0	0	1	1	**3**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Mokhoro	Quthing	**M**	4.36	2	0	0	0	0	0	0	1	1	**4**	0	0	0	0	**4**	0	0	0	0	**6**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Mokhosi	Quthing	**M**	5.93	2	0	0	1	1	0	0	0	0	**3**	1	2	0	0	**4**	0	0	0	0	**0**
Ha Moko	Thaba-Tseka	**M**	6.06	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Mokoafo	Leribe	**M**	11.09	3	1	1	1	1	0	0	0	0	**5**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Mokoekoe	Quthing	**M**	6.39	2	0	0	0	0	0	0	1	1	**3**	0	0	1	1	**9**	0	0	0	0	**1**
Ha Mokolanyane	Mohale's Hoek	**M**	2.34	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Mokone	Mohale's Hoek	**M**	5.14	2	0	0	0	0	0	0	0	0	**9**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Mokone	Mokhotlong	**M**	24.76	7	0	0	1	1	0	0	1	1	**2**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Mokoroane	Berea	**M**	3.61	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Mokotane	Berea	**M**	4.36	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Mokote	Mokhotlong	**M**	2.08	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**4**	0	0	0	0	**1**
Ha Mokotjo	Mohale's Hoek	**M**	3.84	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Mokotjo	Thaba-Tseka	**M**	1.74	1	0	0	1	1	0	0	0	0	**2**	0	0	2	2	**7**	0	0	0	0	**1**
Ha Mokotso	Thaba-Tseka	**M**	11.37	4	0	0	0	0	0	0	1	1	**3**	0	0	2	2	**2**	0	0	0	0	**1**
Ha Mokotso	Mokhotlong	**M**	5.17	2	0	0	0	0	0	0	1	1	**5**	0	0	0	0	**4**	0	0	0	0	**2**
Ha Mokuoane	Thaba-Tseka	**M**	11.85	4	0	0	1	1	0	0	1	1	**6**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Molahli	Mohale's Hoek	**M**	7.34	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Molalanyane	Mohale's Hoek	**M**	4.39	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Molangoana	Maseru	**M**	1.53	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**2**
Ha 'Molaoa	Berea	**M**	2.26	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**6**	0	0	1	1	**3**
Ha Molapo	Qacha's Nek	**M**	3.93	2	0	0	0	0	0	0	0	0	**2**	0	0	3	3	**5**	0	0	0	0	**1**
Ha Molatjeng	Thaba-Tseka	**M**	10.26	3	0	0	1	1	0	0	0	0	**4**	0	0	2	2	**4**	0	0	0	0	**3**
Ha Molebaliso	Thaba-Tseka	**M**	20.86	6	0	0	0	0	0	0	0	0	**6**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Molefe	Berea	**M**	4.59	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**6**	0	0	0	0	**1**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Moleleki	Mohale's Hoek	**M**	4.14	2	0	0	0	0	0	0	1	1	**3**	0	0	1	1	**5**	0	0	0	0	**2**
Ha Molelle	Quthing	**M**	8.35	3	0	0	0	0	0	0	1	1	**4**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Molengoane	Mokhotlong	**M**	7.19	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Moletsane	Quthing	**S**	0.60	1	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Molipa	Leribe	**M**	3.33	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Molisana	Maseru	**M**	0.53	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**0**	0	0	0	0	**2**
Ha Molobeli	Mohale's Hoek	**M**	3.13	1	0	0	0	0	0	0	0	0	**1**	0	0	3	3	**9**	0	0	0	0	**1**
Ha Molofotsane	Leribe	**M**	2.88	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Moloi	Butha-Buthe	**M**	1.55	1	0	0	0	0	0	0	0	0	**0**	0	0	3	3	**8**	0	0	1	1	**7**
Ha Molomo	Maseru	**M**	16.39	5	0	0	0	0	0	0	1	1	**6**	0	0	2	2	**5**	0	0	0	0	**1**
Ha Molotanyane	Thaba-Tseka	**M**	8.99	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Molotha	Maseru	**M**	2.04	1	0	0	1	1	0	0	0	0	**2**	0	0	1	1	**5**	0	0	0	0	**1**
Ha Molungoa	Mohale's Hoek	**M**	3.07	1	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Molungoa	Leribe	**M**	4.55	2	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Monaheng	Berea	**M**	3.92	2	0	0	0	0	0	0	1	1	**3**	0	0	1	1	**2**	0	0	0	0	**2**
Ha Monale	Mokhotlong	**M**	4.65	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Monamoleli	Maseru	**M**	2.85	1	0	0	0	0	0	0	0	0	**1**	0	0	3	3	**5**	0	0	0	0	**1**
Ha Monethi	Mafeteng	**M**	1.13	1	0	0	1	1	0	0	1	1	**3**	0	0	1	1	**2**	0	0	0	0	**2**
Ha Monono	Leribe	**M**	0.35	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**2**
Ha Monoto	Berea	**M**	2.50	1	0	0	1	1	0	0	0	0	**2**	0	0	1	1	**5**	0	0	0	0	**3**
Ha Montso	Berea	**M**	0.03	0	0	0	0	0	0	0	0	0	**0**	0	0	1	1	**3**	0	0	0	0	**2**
Ha Monyai	Mafeteng	**M**	7.38	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Monyake	Quthing	**M**	11.06	3	0	0	1	1	0	0	1	1	**5**	0	0	1	1	**3**	0	0	0	0	**2**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Monyalotsa	Mohale's Hoek	**M**	0.56	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Monyane	Berea	**M**	8.85	3	0	0	0	0	0	0	0	0	**1**	0	0	3	3	**4**	0	0	0	0	**2**
Ha Monyane	Mohale's Hoek	**M**	0.13	1	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**5**	0	0	0	0	**2**
Ha Monyuoe	Mafeteng	**M**	4.15	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	1	1	**4**
Ha Moorosi	Qacha's Nek	**M**	4.06	2	0	0	1	1	0	0	0	0	**3**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Mopeli	Mafeteng	**M**	2.17	1	0	0	1	1	0	0	0	0	**2**	0	0	1	1	**2**	0	0	0	0	**0**
Ha Mopeli	Maseru	**M**	1.03	1	0	0	1	1	0	0	1	1	**3**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Moqalo	Quthing	**M**	7.50	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**3**	0	0	0	0	**2**
Ha Moqekela	Quthing	**M**	1.87	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Moqibi	Berea	**M**	1.30	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Morainyane	Quthing	**M**	0.35	1	0	0	0	0	0	0	0	0	**1**	0	0	4	4	**6**	0	0	0	0	**1**
Ha Moramang	Thaba-Tseka	**M**	1.86	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**6**	0	0	0	0	**2**
Ha Morema	Maseru	**M**	3.24	1	0	0	1	1	0	0	0	0	**2**	0	0	1	1	**4**	0	0	0	0	**2**
Ha Moriana	Maseru	**M**	0.58	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**0**	0	0	0	0	**1**
Ha Moroke	Thaba-Tseka	**M**	16.69	5	0	0	1	1	0	0	1	1	**5**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Moroke	Mohale's Hoek	**M**	8.99	3	0	0	1	1	0	0	1	1	**7**	0	0	2	2	**4**	0	0	0	0	**1**
Ha Moruthoane	Thaba-Tseka	**M**	3.95	2	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**4**	0	0	0	0	**1**
Ha 'Mosa	Maseru	**M**	6.59	2	0	0	0	0	0	0	1	1	**3**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Mosae	Berea	**M**	5.00	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	1	1	**5**
Ha Mosala	Maseru	**M**	0.20	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Mosalla	Quthing	**M**	5.41	2	0	0	1	1	0	0	0	0	**3**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Mosebi	Berea	**S**	0.79	1	0	0	2	2	0	0	2	2	**6**	0	0	1	1	**5**	0	0	0	0	**2**
Ha Mosehle	Mafeteng	**M**	0.18	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	0	0	**2**

Village Name	**District**	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Mosele	Maseru	**M**	0.19	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**9**	0	0	0	0	**2**
Ha Moseli	Qacha's Nek	**M**	14.81	4	0	0	0	0	0	0	1	1	**5**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Moseneke	Quthing	**M**	8.61	3	0	0	1	1	0	0	1	1	**9**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Moseneke	Quthing	**M**	29.72	8	0	0	1	1	0	0	0	0	**5**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Moshebi	Mafeteng	**M**	3.20	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Mosifa	Quthing	**M**	9.20	3	0	0	0	0	0	0	1	1	**4**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Mosiroe	Mohale's Hoek	**M**	3.23	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Mosisi	Qacha's Nek	**S**	0.47	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**4**	0	0	0	0	**1**
Ha Mositi	Quthing	**M**	6.64	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Mosiuoa	Thaba-Tseka	**M**	6.98	2	0	0	1	1	0	0	1	1	**4**	1	2	0	0	**4**	0	0	0	0	**2**
Ha Mosiuoa	Mokhotlong	**M**	4.29	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**11**	0	0	0	0	**4**
Ha Mosuoe	Leribe	**M**	5.07	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Mosututsoana	Qacha's Nek	**M**	4.78	2	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Motaba	Berea	**M**	7.94	3	0	0	1	1	0	0	0	0	**4**	0	0	0	0	**1**	0	0	1	1	**4**
Ha Motamolane	Quthing	**M**	0.74	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Motanyane	Qacha's Nek	**M**	4.02	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**2**	0	0	0	0	**0**
Ha Motanyane	Mafeteng	**M**	1.02	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Motanyane	Mafeteng	**M**	5.51	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Motau	Mokhotlong	**M**	10.46	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Motee	Maseru	**M**	2.81	1	0	0	0	0	0	0	0	0	**1**	0	0	3	3	**7**	0	0	0	0	**1**
Ha Motete	Mafeteng	**M**	0.14	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Mothae	Thaba-Tseka	**M**	10.95	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Mothakathi	Mohale's Hoek	**M**	5.83	2	0	0	0	0	0	0	1	1	**3**	0	0	1	1	**6**	0	0	0	0	**1**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Mothamahane	Leribe	**S**	1.17	1	0	0	0	0	0	0	2	2	**4**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Mothibe	Butha-Buthe	**M**	2.49	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Mothibi	Berea	**M**	18.54	5	0	0	0	0	0	0	0	0	**5**	0	0	1	1	**5**	0	0	0	0	**1**
Ha Mothokho	Leribe	**M**	2.23	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**0**
Ha Mothuntsane	Leribe	**M**	5.33	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Motjoli	Maseru	**M**	10.16	3	0	0	1	1	0	0	1	1	**5**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Motjolopane	Mafeteng	**S**	0.86	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Motjotji	Butha-Buthe	**M**	0.09	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Motlau	Quthing	**M**	4.32	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**4**	0	0	0	0	**1**
Ha Motlhotlo	Thaba-Tseka	**M**	5.25	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**4**	0	0	0	0	**1**
Ha Motloheloa	Maseru	**S**	0.32	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Motlokoa	Leribe	**M**	13.25	4	0	0	0	0	0	0	0	0	**4**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Motoko	Thaba-Tseka	**M**	12.12	4	0	0	0	0	0	0	0	0	**4**	0	0	0	0	**6**	0	0	0	0	**1**
Ha Motopi	Maseru	**M**	0.50	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Motsapi	Mafeteng	**M**	2.82	1	0	0	0	0	0	0	1	1	**6**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Motsapi	Maseru	**M**	9.34	3	0	0	3	3	0	0	0	0	**2**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Motseare	Mohale's Hoek	**M**	0.92	1	0	0	1	1	0	0	0	0	**2**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Motsiba	Quthing	**M**	4.36	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Motsie	Quthing	**M**	6.24	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**4**	0	0	0	0	**2**
Ha Motsieloa	Mokhotlong	**M**	2.94	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Motsieloa	Thaba-Tseka	**M**	7.49	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	1	1	**3**
Ha Motsoari	Maseru	**M**	11.90	4	0	0	0	0	0	0	1	1	**5**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Motsoene	Berea	**M**	3.77	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**0**	0	0	0	0	**1**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Mpalipali	Quthing	**M**	1.41	1	0	0	1	1	0	0	1	1	**3**	0	0	1	1	**3**	0	0	0	0	**2**
Ha Mpao	Quthing	**M**	7.60	3	0	0	1	1	0	0	5	5	**9**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Mpapa	Berea	**M**	0.09	0	0	0	0	0	0	0	0	0	**0**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Mpeka	Mafeteng	**M**	0.86	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	0	0	**2**
Ha Mpeli	Maseru	**M**	2.30	1	0	0	0	0	0	0	0	0	**0**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Mpeli	Quthing	**M**	6.84	2	0	0	1	1	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Mpeli	Quthing	**M**	0.04	0	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Mphahama	Leribe	**M**	2.99	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	1	1	**6**
Ha Mphaololi	Maseru	**M**	7.08	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Mphaololi	Leribe	**M**	0.10	0	0	0	0	0	0	0	0	0	**0**	0	0	1	1	**11**	0	0	0	0	**1**
Ha Mphasa	Qacha's Nek	**M**	0.38	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Mphatsoane	Mafeteng	**M**	0.14	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	0	0	**2**
Ha Mphele	Mafeteng	**M**	5.84	2	0	0	1	1	0	0	0	0	**3**	0	0	5	5	**7**	0	0	0	0	**1**
Ha Mpheulane	Mafeteng	**M**	5.74	2	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**4**	0	0	0	0	**1**
Ha Mpheulane	Mafeteng	**M**	2.96	1	0	0	1	1	0	0	0	0	**3**	0	0	1	1	**3**	0	0	0	0	**2**
Ha Mpho	Berea	**M**	0.77	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Mphulanyane	Mokhotlong	**M**	8.04	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Mpiko	Maseru	**M**	7.84	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**7**	0	0	1	1	**6**
Ha Mpiti	Thaba-Tseka	**M**	6.82	2	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Mpoba	Mafeteng	**M**	8.16	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**5**	0	0	0	0	**1**
Ha Mpolokoana	Thaba-Tseka	**M**	20.95	6	0	0	1	1	0	0	1	1	**8**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Mpshe	Maseru	**M**	4.29	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Mtlomele	Berea	**M**	1.76	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**2**

Village Name	**District**	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Nakeli	Mohale's Hoek	**M**	11.11	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Nang	Berea	**M**	2.95	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Napo	Qacha's Nek	**M**	0.98	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Napo	Thaba-Tseka	**M**	0.52	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	0	0	**3**
Ha 'Natla	Leribe	**M**	1.94	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	0	0	**1**
Ha Nchela	Butha-Buthe	**M**	0.12	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Nchoatla	Leribe	**M**	9.73	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Nchoba	Thaba-Tseka	**M**	9.73	3	0	0	3	3	0	0	0	0	**6**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Nchoba	Maseru	**M**	1.89	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Ncoalane	Butha-Buthe	**M**	6.61	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Nehee	Mohale's Hoek	**S**	0.34	1	0	0	0	0	0	0	1	1	**3**	0	0	1	1	**5**	0	0	0	0	**2**
Ha 'Nete	Mohale's Hoek	**M**	9.97	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Ngheku	Mafeteng	**M**	0.13	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Nkati	Leribe	**M**	0.14	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Nkau	Mohale's Hoek	**M**	6.64	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Nkeo	Maseru	**M**	0.33	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Nkhahle	Quthing	**M**	4.36	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**0**
Ha Nkhahle	Mohale's Hoek	**M**	4.07	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**3**	0	0	0	0	**2**
Ha Nkhaulise	Mafeteng	**S**	0.66	1	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Nkhokho	Qacha's Nek	**S**	0.75	1	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Nkisi	Berea	**M**	8.57	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Nkofo	Thaba-Tseka	**M**	7.52	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**6**	0	0	0	0	**1**
Ha Nkohoto	Mafeteng	**M**	2.07	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Nkoko	Leribe	**M**	2.27	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Nkokoane	Qacha's Nek	**M**	17.94	5	0	0	1	1	0	0	0	0	**6**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Nkopa	Mohale's Hoek	**M**	2.44	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Nkotane	Qacha's Nek	**M**	1.22	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Nkoto	Thaba-Tseka	**M**	0.21	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Nkube	Leribe	**M**	2.51	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Nkuebe	Mokhotlong	**M**	4.80	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Nkunyane	Quthing	**M**	1.98	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**3**
Ha Noha	Quthing	**M**	0.56	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Nohana	Berea	**M**	10.53	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Nokoane	Thaba-Tseka	**M**	1.85	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Noosi	Thaba-Tseka	**M**	1.09	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**4**	0	0	0	0	**2**
Ha Noto	Mohale's Hoek	**M**	2.20	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Notsi	Thaba-Tseka	**M**	1.97	1	0	0	0	0	0	0	1	1	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Notsi	Qacha's Nek	**M**	0.23	1	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Nqabeni	Mohale's Hoek	**M**	7.44	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**5**
Ha Nqosa	Berea	**M**	2.86	1	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Ntabanyane	Mafeteng	**M**	0.50	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Ntahli	Butha-Buthe	**M**	0.24	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Ntake	Maseru	**M**	3.47	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**5**	0	0	0	0	**1**
Ha Ntanyele	Mohale's Hoek	**M**	2.05	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Ntaote	Leribe	**M**	8.37	3	0	0	2	2	0	0	0	0	**5**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Ntebele	Thaba-Tseka	**M**	17.70	5	0	0	3	3	0	0	0	0	**8**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Ntemere	Mafeteng	**M**	3.42	1	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Nthafa	Mafeteng	**M**	3.15	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	0	0	**1**
Ha Nthamae	Leribe	**S**	0.74	1	0	0	2	2	0	0	2	2	**6**	0	0	0	0	**4**	0	0	0	0	**4**
Ha Nthapo	Quthing	**M**	0.52	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**

Village Name	**District**	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Nthathakane	Berea	**M**	9.12	3	0	0	1	1	0	0	1	1	**5**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Nthimolane	Mohale's Hoek	**M**	9.02	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**8**	0	0	0	0	**4**
Ha Ntho	Maseru	**M**	6.81	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**4**
Ha Ntholi	Maseru	**S**	0.36	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Nthonyana	Mokhotlong	**M**	10.30	3	2	2	3	3	0	0	0	0	**8**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Ntisa	Quthing	**M**	0.18	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	1	1	**4**
Ha Ntja	Leribe	**M**	3.26	1	0	0	0	0	0	0	0	0	**1**	0	0	2	2	**6**	0	0	0	0	**2**
Ha Ntjanyana	Mafeteng	**M**	0.52	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**5**	0	0	0	0	**1**
Ha Ntjolo	Berea	**M**	6.84	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Ntlama	Mohale's Hoek	**M**	11.81	4	0	0	0	0	0	0	1	1	**5**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Ntlama	Mohale's Hoek	**M**	15.51	5	0	0	0	0	0	0	1	1	**6**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Ntlhasinye	Mokhotlong	**M**	7.83	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Ntoahae	Maseru	**M**	0.75	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Ntopo	Berea	**M**	3.06	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Ntsane	Mohale's Hoek	**M**	5.16	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Ntsapi	Mohale's Hoek	**M**	3.27	1	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Ntsasa	Thaba-Tseka	**M**	5.37	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Ntseke	Maseru	**M**	3.28	1	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Ntseke	Mohale's Hoek	**M**	1.23	1	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**2**	0	0	0	0	**5**
Ha Ntseli	Thaba-Tseka	**M**	5.96	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Ntsesenyane	Leribe	**M**	6.12	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Ntsi	Thaba-Tseka	**M**	0.36	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Ntsoha	Leribe	**M**	4.06	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**4**	0	0	0	0	**1**
Ha Ntsokoane	Mokhotlong	**M**	0.50	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Ntsonyane	Maseru	**M**	0.14	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Nyakane	Leribe	**M**	0.16	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha 'Nyane	Mohale's Hoek	**M**	10.78	3	0	0	0	0	0	0	1	1	**4**	0	0	0	0	**0**	0	0	0	0	**1**
Ha 'Nyape	Mafeteng	**M**	6.45	2	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Oalatsa	Maseru	**M**	6.24	2	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**3**	0	0	0	0	**3**
Ha Oetsi	Thaba-Tseka	**M**	0.10	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	**5**	0	0	0	0	**3**
Ha Oni	Mohale's Hoek	**M**	9.68	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**4**	0	0	0	0	**2**
Ha Oropeng	Mohale's Hoek	**M**	8.40	3	0	0	0	0	0	0	1	1	**4**	0	0	0	0	**6**	0	0	0	0	**1**
Ha Oropeng	Mohale's Hoek	**M**	17.84	5	0	0	0	0	0	0	1	1	**6**	0	0	0	0	**3**	0	0	0	0	**2**
Ha Osteng	Mafeteng	**M**	4.40	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Paepae	Thaba-Tseka	**M**	10.72	3	0	0	0	0	0	0	1	1	**4**	0	0	0	0	**4**	0	0	1	1	**4**
Ha Paka	Thaba-Tseka	**M**	9.19	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Paki	Maseru	**M**	2.51	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Pakiso	Maseru	**M**	12.05	4	0	0	3	3	0	0	0	0	**7**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Palama	Leribe	**M**	2.92	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Panta	Mafeteng	**M**	4.31	2	0	0	1	1	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Panta	Maseru	**M**	1.86	1	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Paramente	Leribe	**M**	9.01	3	0	0	0	0	0	0	1	1	**4**	0	0	0	0	**0**	0	0	0	0	**1**
Ha Pasta	Mafeteng	**M**	5.84	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Patrick	Mohale's Hoek	**S**	0.17	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Peete	Butha-Buthe	**M**	0.05	0	0	0	2	2	0	0	0	0	**2**	1	2	0	0	**5**	0	0	0	0	**1**
Ha Peete	Leribe	**M**	9.85	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**3**	0	0	0	0	**2**
Ha Pelei	Maseru	**M**	2.40	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Pelele	Leribe	**M**	6.85	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Pentsi	Quthing	**M**	8.60	3	0	0	0	0	0	0	1	1	**4**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Pesto	Maseru	**M**	2.38	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Petlane	Berea	**M**	7.64	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**0**
Ha Petrose	Leribe	**M**	4.58	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**4**	0	0	0	0	**4**
Ha Phaja	Maseru	**M**	3.15	1	0	0	1	1	0	0	1	1	**3**	0	0	1	1	**3**	0	0	0	0	**4**
Ha Phakiso	Mafeteng	**M**	2.74	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**2**
Ha Phakoe	Thaba-Tseka	**M**	9.99	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Phallang	Mohale's Hoek	**M**	0.57	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Phalo	Berea	**M**	4.71	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**5**	0	0	1	1	**4**
Ha Phaloane	Mafeteng	**M**	6.20	2	0	0	0	0	0	0	0	0	**4**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Phaloane	Maseru	**S**	0.18	1	0	0	1	1	0	0	1	1	**2**	0	0	1	1	**2**	0	0	0	0	**2**
Ha Phalole	Mohale's Hoek	**M**	12.97	4	0	0	0	0	0	0	1	1	**1**	0	0	1	1	**1**	0	0	0	0	**1**
Ha Phalole	Maseru	**M**	1.31	1	0	0	0	0	0	0	0	0	**5**	0	0	0	0	**3**	0	0	0	0	**3**
Ha Pheello	Maseru	**M**	0.39	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Pheello	Leribe	**M**	1.20	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Phepheng	Leribe	**M**	2.75	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**9**	0	0	0	0	**1**
Ha Phohleli	Quthing	**M**	8.29	3	0	0	0	0	0	0	1	1	**4**	0	0	1	1	**6**	0	0	0	0	**1**
Ha Phoka	Qacha's Nek	**M**	3.53	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Phole	Mokhotlong	**M**	17.00	5	1	1	1	1	0	0	0	0	**7**	0	0	1	1	**3**	0	0	0	0	**2**
Ha Phoofolo	Maseru	**M**	0.23	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Phooko	Quthing	**M**	3.79	2	0	0	0	0	0	0	1	1	**3**	0	0	1	1	**3**	0	0	1	1	**4**
Ha Pii	Mohale's Hoek	**M**	5.98	2	0	0	0	0	0	0	1	1	**3**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Pitsi	Berea	**M**	5.04	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**2**	0	0	1	1	**6**
Ha Pitso	Leribe	**M**	6.52	2	0	0	0	0	0	0	0	0	**2**	0	0	2	2	**5**	0	0	0	0	**1**
Ha Poko	Mohale's Hoek	**M**	0.50	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**7**	0	0	0	0	**1**
Ha Pokola	Thaba-Tseka	**M**	7.94	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Polaki	Thaba-Tseka	**M**	19.17	6	0	0	0	0	0	0	0	0	**6**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Polane	Mohale's Hoek	**M**	1.03	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**1**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Poli	Leribe	**M**	1.23	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**2**
Ha Poliarote	Mohale's Hoek	**M**	4.95	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Poosho	Leribe	**M**	0.14	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Popa	Mafeteng	**M**	1.89	1	0	0	1	1	0	0	1	1	**3**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Popolosi	Butha-Buthe	**M**	0.65	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Poranc	Thaba-Tseka	**M**	10.24	3	0	0	1	1	0	0	0	0	**4**	0	0	1	1	**3**	0	0	0	0	**3**
Ha Potiane	Mohale's Hoek	**M**	4.41	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Potjo	Maseru	**M**	2.97	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	0	0	**6**
Ha Potomane	Maseru	**S**	0.41	1	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**3**	0	0	1	1	**3**
Ha Potso	Butha-Buthe	**M**	1.18	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Pshatlella	Quthing	**M**	0.07	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	**4**	0	0	0	0	**1**
Ha Puoane	Quthing	**M**	6.32	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Qaba	Maseru	**M**	6.93	2	2	2	3	3	0	0	1	1	**8**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Qamako	Berea	**M**	5.28	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**4**	0	0	0	0	**1**
Ha Qhoesha	Mafeteng	**S**	0.52	1	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Qiqita	Maseru	**M**	8.11	3	0	0	0	0	0	0	1	1	**4**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Qoane	Maseru	**M**	5.05	2	0	0	1	1	0	0	1	1	**1**	0	0	0	0	**0**	0	0	0	0	**1**
Ha Qoane	Mohale's Hoek	**M**	0.32	1	0	0	0	0	0	0	0	0	**4**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Qoi	Thaba-Tseka	**M**	2.44	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Rabeleng	Mohale's Hoek	**M**	0.07	0	0	0	0	0	0	0	0	0	**0**	0	0	1	1	**3**	0	0	0	0	**0**
Ha Raboko		**M**	2.90	1	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**2**	0	0	1	1	**4**
Ha Raboletsi	Mafeteng	**M**	0.43	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Rabotsoa	Mohale's Hoek	**M**	4.85	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**4**	0	0	0	0	**4**
Ha Rachabana	Maseru	**S**	0.27	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**3**	0	0	0	0	**2**
Ha Raemile	Maseru	**M**	5.89	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**8**	0	0	0	0	**1**
Ha Rafanyane	Mohale's Hoek	**M**	11.17	3	0	0	0	0	0	0	1	1	**4**	0	0	1	1	**3**	0	0	0	0	**2**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Rafolatsane	Quthing	**M**	24.23	7	0	0	1	1	0	0	1	1	**9**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Rajoalane	Leribe	**M**	3.16	1	0	0	3	3	0	0	1	1	**5**	0	0	1	1	**3**	0	0	0	0	**3**
Ha Rakalo	Mokhotlong	**M**	0.57	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Rakhoboli	Thaba-Tseka	**M**	0.39	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	1	1	**4**
Ha Rakhoboso	Leribe	**M**	0.13	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Rakhomo	Quthing	**M**	0.34	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Rakoloi	Maseru	**M**	3.89	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Rakulubane	Quthing	**M**	0.13	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Ralebese	Berea	**M**	1.15	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Ralebona	Mohale's Hoek	**M**	4.04	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**3**	0	0	0	0	**4**
Ha Ralefatla	Leribe	**M**	4.94	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**6**	0	0	0	0	**3**
Ha Ralehlatsa	Quthing	**M**	10.04	3	0	0	1	1	0	0	0	0	**4**	0	0	0	0	**4**	0	0	0	0	**1**
Ha Ralengoele	Mokhotlong	**M**	20.95	6	0	0	1	1	0	0	1	1	**8**	0	0	0	0	**9**	0	0	0	0	**1**
Ha Raliemere	Leribe	**M**	7.91	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Ralikuku	Qacha's Nek	**M**	9.86	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Ralimpe	Mafeteng	**M**	2.37	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Ralinko	Leribe	**M**	3.26	1	0	0	0	0	0	0	2	2	**3**	0	0	0	0	**4**	0	0	0	0	**1**
Ha Ralinomore	Mohale's Hoek	**M**	6.82	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Raliopelo	Butha-Buthe	**M**	11.42	4	0	0	0	0	0	0	0	0	**4**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Ralitaba	Maseru	**M**	4.82	2	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**2**	0	0	0	0	**4**
Ha Ralitlhare	Mafeteng	**M**	4.09	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Ralitseko	Mafeteng	**M**	6.35	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Ralitsibane	Mokhotlong	**M**	8.77	3	0	0	0	0	0	0	1	1	**4**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Ramabele	Maseru	**S**	0.22	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**2**	0	0	0	0	**2**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Ramabele	Mohale's Hoek	**M**	6.53	2	0	0	0	0	0	0	1	1	**3**	0	0	1	1	**3**	0	0	1	1	**4**
Ha Ramaepho	Berea	**M**	5.72	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**5**	0	0	0	0	**1**
Ha Ramahlaela	Maseru	**M**	0.42	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Ramahlape	Thaba-Tseka	**M**	14.60	4	0	0	1	1	0	0	1	1	**6**	0	0	1	1	**7**	0	0	0	0	**1**
Ha Ramahotetsa	Qacha's Nek	**M**	0.58	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Ramajalle	Mafeteng	**M**	0.09	0	0	0	0	0	0	0	0	0	**0**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Ramakhooa	Mafeteng	**M**	2.61	1	0	0	0	0	0	0	1	1	**2**	0	0	2	2	**5**	0	0	0	0	**1**
Ha Ramakoe	Thaba-Tseka	**M**	6.85	2	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Ramanamane	Mafeteng	**M**	9.34	3	0	0	0	0	0	0	1	1	**4**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Ramaolosi	Mafeteng	**M**	2.90	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Ramaomane	Leribe	**M**	2.00	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**5**	0	0	0	0	**1**
Ha Ramapane	Thaba-Tseka	**M**	3.52	1	0	0	0	0	0	0	0	0	**1**	0	0	2	2	**4**	0	0	0	0	**1**
Ha Ramapepe	Thaba-Tseka	**M**	14.99	4	0	0	0	0	0	0	0	0	**4**	0	0	3	3	**5**	0	0	0	0	**1**
Ha Ramapniri	Qacha's Nek	**S**	0.84	1	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Ramaqhanyane	Leribe	**M**	0.51	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	1	1	**4**
Ha Ramarebosta	Maseru	**M**	4.42	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Ramarothole	Maseru	**M**	2.00	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**3**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Ramasokoana	Thaba-Tseka	**M**	4.00	2	0	0	0	0	0	0	0	0	**2**	1	2	1	1	**5**	0	0	0	0	**1**
Ha Ramatatiele	Mafeteng	**M**	0.70	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**6**	0	0	1	1	**4**
Ha Ramatekane	Maseru	**M**	7.16	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Ramathaha	Mohale's Hoek	**M**	20.35	6	0	0	0	0	0	0	1	1	**7**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Ramatlali	Maseru	**M**	4.26	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**3**
Ha Ramatlalla	Mafeteng	**M**	6.99	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**3**
Ha Ramatseliso	Mohale's Hoek	**M**	2.68	1	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**6**	0	0	0	0	**1**
Ha Rammeleke	Mohale's Hoek	**M**	2.65	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Rammuso	Thaba-Tseka	**M**	18.94	6	0	0	0	0	0	0	0	0	**6**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Ramochana	Mokhotlong	**M**	5.51	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**6**	0	0	0	0	**2**
Ha Ramohajana	Mafeteng	**M**	2.58	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Ramohale	Leribe	**M**	16.23	5	0	0	0	0	0	0	0	0	**5**	0	0	0	0	**1**	0	0	1	1	**4**
Ha Ramohdli	Maseru	**M**	0.22	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Ramohlolonyane	Mokhotlong	**M**	1.27	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Ramohots	Qacha's Nek	**S**	0.39	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Ramoji	Mohale's Hoek	**M**	1.08	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Ramokakatlela	Mohale's Hoek	**M**	0.29	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	0	0	**3**
Ha Ramokhele	Leribe	**M**	7.50	2	0	0	0	0	0	0	1	1	**3**	0	0	5	5	**8**	0	0	1	1	**6**
Ha Ramokitim	Qacha's Nek	**M**	12.86	4	0	0	0	0	0	0	0	0	**4**	0	0	0	0	**1**	0	0	0	0	**0**
Ha Ramokoatsi	Mafeteng	**M**	4.39	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**4**
Ha Ramokoena	Maseru	**M**	2.52	1	0	0	0	0	0	0	2	2	**3**	0	0	0	0	**1**	0	0	0	0	**3**
Ha Ramokone	Thaba-Tseka	**M**	1.06	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Ramokotla	Mafeteng	**M**	0.52	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Ramoliehi	Maseru	**M**	1.56	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Ramololi	Mohale's Hoek	**M**	2.04	1	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Ramonate	Quthing	**M**	9.08	3	0	0	1	1	0	0	1	1	**5**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Ramoreki	Mohale's Hoek	**M**	5.28	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Ramoroba	Mohale's Hoek	**M**	0.44	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Ramoroke	Mafeteng	**M**	3.28	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Ramosalla	Qacha's Nek	**S**	0.11	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**4**	0	0	0	0	**1**
Ha Ramosebo	Qacha's Nek	**M**	2.85	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Ramoseeka	Leribe	**M**	12.99	4	0	0	0	0	0	0	0	0	**4**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Ramosoeu	Maseru	**M**	2.11	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**6**	0	0	0	0	**1**
Ha Ramotete	Maseru	**M**	4.07	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Ramotha	Mokhotlong	**M**	9.75	3	2	2	3	3	0	0	1	1	**9**	0	0	0	0	**2**	0	0	0	0	**0**
Ha Ramothobi	Berea	**M**	3.22	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Rampa	Berea	**M**	1.38	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Rampai	Mohale's Hoek	**M**	5.20	2	0	0	3	3	0	0	0	0	**5**	0	0	0	0	**3**	0	0	0	0	**1**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Rampeo	Leribe	**M**	4.70	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Rampoetsi	Butha-Buthe	**M**	8.23	3	0	0	1	1	0	0	0	0	**4**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Rankakala	Quthing	**M**	7.60	3	0	0	1	1	0	0	0	0	**4**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Rankali	Maseru	**S**	0.27	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Rankhakile	Qacha's Nek	**M**	0.37	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**0**
Ha Rankhelepe	Mohale's Hoek	**M**	6.18	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Rankhoba	Mohale's Hoek	**M**	6.67	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**4**	0	0	0	0	**4**
Ha Ranko	Maseru	**M**	3.10	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Rankomo	Mohale's Hoek	**M**	14.91	4	0	0	1	1	0	0	1	1	**6**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Rannini	Mafeteng	**M**	6.72	2	0	0	0	0	0	0	0	0	**2**	2	4	0	0	**15**	0	0	0	0	**3**
Ha Rannoto	Thaba-Tseka	**M**	0.80	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	1	1	**4**
Ha Ranqhongoana	Mokhotlong	**M**	14.19	4	3	3	3	3	0	0	1	1	**11**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Ranthiba	Maseru	**M**	1.40	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Ranthokoe	Qacha's Nek	**M**	2.19	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**3**
Ha Ranthoto	Berea	**M**	5.44	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**4**	0	0	0	0	**1**
Ha Rantofi	Butha-Buthe	**M**	6.24	2	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**1**	0	0	0	0	**3**
Ha Rantsala	Thaba-Tseka	**M**	5.86	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**4**
Ha Rantsetse	Mohale's Hoek	**M**	0.69	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**0**
Ha Rantsie	Leribe	**M**	0.38	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Rantsoepela	Maseru	**S**	0.20	1	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**5**	0	0	0	0	**3**
Ha Rantuba	Mohale's Hoek	**M**	0.54	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**5**	0	0	0	0	**1**
Ha Raphae	Quthing	**M**	3.40	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**3**	0	0	0	0	**2**
Ha Rapoeea	Leribe	**M**	14.95	4	0	0	0	0	0	0	0	0	**4**	0	0	0	0	**0**	0	0	0	0	**2**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Rapokane	Maseru	**M**	0.09	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Rapokolana	Thaba-Tseka	**M**	0.06	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	**3**	0	0	1	1	**4**
Ha Rasebolelo	Mafeteng	**M**	2.25	1	0	0	1	1	0	0	1	1	**3**	0	0	1	1	**2**	0	0	1	1	**5**
Ha Rasefale	Maseru	**M**	8.90	3	1	1	1	1	0	0	0	0	**5**	0	0	0	0	**1**	0	0	1	1	**6**
Ha Rasekila	Mohale's Hoek	**M**	1.98	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Raselepe	Mohale's Hoek	**M**	1.80	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**3**
Ha Rasemene	Butha-Buthe	**M**	0.58	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**4**
Ha Rasepelemane	Mohale's Hoek	**M**	0.67	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Rasephokoana	Quthing	**M**	6.35	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**4**	0	0	0	0	**1**
Ha Rashaba	Quthing	**M**	2.13	1	0	0	1	1	0	0	0	0	**2**	0	0	1	1	**2**	0	0	0	0	**4**
Ha Ratau	Maseru	**M**	9.15	3	0	0	1	1	0	0	1	1	**5**	0	0	1	1	**3**	0	0	0	0	**3**
Ha Ratau	Mohale's Hoek	**M**	2.59	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**4**
Ha Ratene	Maseru	**M**	4.41	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**0**	0	0	0	0	**0**
Ha Rateronke	Maseru	**M**	0.40	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Ratjeka	Qacha's Nek	**S**	0.03	0	0	0	1	1	0	0	1	1	**3**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Ratomo	Qacha's Nek	**M**	3.30	1	0	0	0	0	0	0	1	1	**2**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Ratsele	Quthing	**M**	5.06	2	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**3**	0	0	0	0	**2**
Ha Ratsitso	Berea	**M**	4.92	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**3**	0	0	0	0	**3**
Ha Ratsiu	Butha-Buthe	**M**	7.02	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**3**
Ha Ratsosane	Quthing	**M**	8.82	3	0	0	1	1	0	0	1	1	**5**	0	0	0	0	**6**	0	0	0	0	**2**
Ha Raubi	Qacha's Nek	**M**	4.86	2	0	0	0	0	0	0	1	1	**3**	0	0	1	1	**2**	0	0	1	1	**5**
Ha Robi	Thaba-Tseka	**M**	16.14	5	0	0	0	0	0	0	0	0	**5**	0	0	1	1	**3**	0	0	0	0	**3**
Ha Roelane	Mohale's Hoek	**M**	3.15	1	0	0	1	1	0	0	0	0	**2**	0	0	1	1	**3**	0	0	0	0	**2**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Rooijane	Quthing	**M**	0.18	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	0	0	**5**
Ha Rosemane	Quthing	**M**	2.07	1	0	0	0	0	0	0	2	2	**3**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Sakoane	Qacha's Nek	**M**	2.09	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**2**
Ha Salae	Mokhotlong	**M**	1.78	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Salemane	Berea	**M**	0.52	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**5**	0	0	0	0	**3**
Ha Salemone Senqunyane	Mafeteng	**M**	4.56	2	0	0	1	1	0	0	0	0	**3**	0	0	1	1	**4**	0	0	1	1	**4**
Ha Samuel	Mohale's Hoek	**M**	10.73	3	0	0	1	1	0	0	1	1	**5**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Sankatana	Maseru	**M**	0.51	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	1	1	**4**
Ha Sankoe	Maseru	**S**	0.79	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Seabata	Mohale's Hoek	**M**	0.43	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Seala	Maseru	**M**	3.86	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Sebaki	Mokhotlong	**M**	1.29	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**10**	0	0	0	0	**1**
Ha Sebata	Berea	**M**	0.09	0	0	0	0	0	0	0	0	0	**0**	0	0	1	1	**3**	0	0	1	1	**4**
Ha Sebatahali	Mafeteng	**M**	3.86	2	0	0	1	1	0	0	0	0	**3**	1	2	0	0	**6**	0	0	1	1	**3**
Ha Sebatli	Qacha's Nek	**M**	6.74	2	0	0	0	0	0	0	1	1	**3**	0	0	1	1	**3**	0	0	0	0	**2**
Ha Seboche	Berea	**M**	14.99	4	0	0	0	0	0	0	1	1	**5**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Sebophe	Mafeteng	**M**	6.34	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**4**
Ha Sebotha	Butha-Buthe	**M**	0.41	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Sechaba	Butha-Buthe	**M**	0.75	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Sechaba	Leribe	**M**	1.00	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**4**
Ha Sechubata	Mafeteng	**S**	0.35	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Seeiso	Mafeteng	**M**	1.30	1	0	0	1	1	0	0	0	0	**1**	0	0	0	0	**4**	0	0	0	0	**1**
Ha Seeiso	Leribe	**M**	1.42	1	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**1**	0	0	0	0	**3**
Ha Seeiso	Mafeteng	**M**	2.87	1	0	0	1	1	0	0	0	0	**2**	0	0	1	1	**4**	0	0	1	1	**5**
Ha Seeta	Mafeteng	**M**	8.46	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**4**	0	0	0	0	**2**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Seetsa	Maseru	**M**	1.73	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Seetsa	Maseru	**M**	10.20	3	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**3**
Ha Sefako	Leribe	**S**	0.21	1	0	0	2	2	0	0	2	2	**6**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Sefehle	Leribe	**M**	5.54	2	0	0	2	2	0	0	0	0	**4**	0	0	0	0	**3**	0	0	0	0	**2**
Ha Sehlabo	Butha-Buthe	**M**	0.25	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**3**
Ha Sehlahla	Mohale's Hoek	**M**	9.73	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Sehloho	Mafeteng	**S**	0.18	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Seiboko	Thaba-Tseka	**M**	2.15	1	0	0	1	1	0	0	1	1	**3**	0	0	1	1	**10**	0	0	0	0	**1**
Ha Seithati	Qacha's Nek	**S**	0.73	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**6**	0	0	0	0	**4**
Ha Sejahosi	Maseru	**M**	1.75	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	1	1	**5**
Ha Sekake	Mohale's Hoek	**M**	12.76	4	0	0	0	0	0	0	1	1	**5**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Sekantsi	Quthing	**M**	7.99	3	0	0	1	1	0	0	0	0	**4**	0	0	0	0	**3**	0	0	0	0	**3**
Ha Sekete	Mohale's Hoek	**M**	4.72	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	1	1	**2**
Ha Sekhaupane	Maseru	**M**	2.48	1	0	0	1	1	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Sekhaupane	Maseru	**M**	0.31	1	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**7**	0	0	0	0	**1**
Ha Sekhebetlela	Mafeteng	**M**	22.41	6	0	0	0	0	0	0	0	0	**6**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Sekheke	Thaba-Tseka	**S**	0.22	1	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**2**	0	0	0	0	**0**
Ha Sekhobe	Mohale's Hoek	**M**	5.61	2	0	0	0	0	0	0	1	1	**3**	0	0	1	1	**4**	0	0	1	1	**2**
Ha Sekhobe	Mafeteng	**M**	1.22	1	0	0	1	1	0	0	1	1	**3**	0	0	1	1	**7**	0	0	0	0	**5**
Ha Sekhohola	Butha-Buthe	**M**	15.94	5	0	0	1	1	0	0	0	0	**6**	0	0	1	1	**3**	0	0	1	1	**4**
Ha Sekhonyana	Quthing	**M**	5.06	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Sekila	Thaba-Tseka	**M**	0.20	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	0	0	**1**

Village Name	**District**	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Sekoala	Leribe	**M**	1.32	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Sekoala	Thaba-Tseka	**M**	11.34	4	0	0	0	0	0	0	1	1	**5**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Sekoati	Berea	**M**	6.94	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Sekoati	Maseru	**S**	0.90	1	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Sekolopata	Mohale's Hoek	**M**	0.74	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	1	1	**3**
Ha Sekonyela	Butha-Buthe	**M**	0.16	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Seleitara	Thaba-Tseka	**M**	11.87	4	0	0	3	3	0	0	0	0	**7**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Selema	Mohale's Hoek	**M**	4.39	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Seliane	Quthing	**M**	0.18	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Sello	Mohale's Hoek	**M**	3.36	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	0	0	**1**
Ha Selomo	Mohale's Hoek	**S**	0.87	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Selomo	Butha-Buthe	**M**	9.67	3	0	0	1	1	0	0	0	0	**4**	0	0	0	0	**1**	0	0	0	0	**3**
Ha Sematle	Butha-Buthe	**M**	2.28	1	0	0	2	2	0	0	0	0	**3**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Semenyane	Butha-Buthe	**M**	0.49	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Semphi	Maseru	**S**	0.50	1	0	0	1	1	0	0	1	1	**4**	0	0	2	2	**11**	0	0	0	0	**1**
Ha Senekane	Qacha's Nek	**S**	0.13	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**4**	0	0	1	1	**1**
Ha Senekane	Thaba-Tseka	**M**	9.26	3	0	0	0	0	0	0	1	1	**4**	0	0	2	2	**2**	0	0	0	0	**4**
Ha Senkoase	Mokhotlong	**M**	5.34	2	0	0	0	0	0	0	0	0	**2**	0	0	3	3	**7**	0	0	0	0	**3**
Ha Sentso	Berea	**M**	0.19	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**5**	0	0	0	0	**2**
Ha Senyokotho	Mokhotlong	**M**	8.28	3	0	0	0	0	0	0	0	0	**3**	0	0	3	3	**5**	0	0	0	0	**2**
Ha Seoehlana	Mohale's Hoek	**M**	7.64	3	0	0	3	3	0	0	1	1	**7**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Seohapo	Leribe	**M**	0.86	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Seotsa	Maseru	**M**	0.34	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**2**
Ha Sepechele	Mohale's Hoek	**M**	5.54	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**2**	0	0	0	0	**1**

Village Name	**District**	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Sepelema	Maseru	**M**	3.97	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**3**
Ha Sephapo	Mafeteng	**M**	0.04	0	0	0	0	0	0	0	0	0	**0**	0	0	2	2	**4**	0	0	0	0	**4**
Ha Sephelane	Mafeteng	**M**	0.75	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**5**
Ha Sephoko	Leribe	**M**	4.78	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Sephula	Qacha's Nek	**M**	4.25	2	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Sepinare	Maseru	**M**	3.07	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**5**	0	0	0	0	**1**
Ha Sepinare	Mafeteng	**M**	1.18	1	0	0	0	0	0	0	0	0	**1**	0	0	2	2	**4**	0	0	0	0	**3**
Ha Sepirti	Leribe	**M**	2.09	1	1	1	3	3	0	0	0	0	**5**	0	0	0	0	**2**	0	0	0	0	**3**
Ha Seqhoe	Mohale's Hoek	**M**	0.60	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	1	1	**4**
Ha Setai	Thaba-Tseka	**M**	1.40	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**5**
Ha Setala	Thaba-Tseka	**M**	2.87	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Setebatebe	Thaba-Tseka	**M**	4.17	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**4**	0	0	0	0	**1**
Ha Setefane	Maseru	**M**	3.85	2	0	0	0	0	0	0	1	1	**3**	1	2	0	0	**4**	0	0	1	1	**5**
Ha Setenane	Mohale's Hoek	**M**	12.81	4	0	0	0	0	0	0	0	0	**4**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Setene	Qacha's Nek	**M**	1.70	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**7**	0	0	0	0	**1**
Ha Sethuamajoe	Maseru	**M**	1.75	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Setjeo	Maseru	**M**	14.51	4	2	2	3	3	0	0	1	1	**10**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Setlakotlako	Maseru	**M**	1.14	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Setlhotlelo	Leribe	**M**	3.53	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Setlolela	Mafeteng	**M**	1.92	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Setofolo	Mohale's Hoek	**M**	4.58	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**0**
Ha Setoko	Mafeteng	**M**	4.17	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**4**	0	0	0	0	**2**
Ha Setoko	Qacha's Nek	**M**	2.33	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**3**
Ha Setone	Mokhotlong	**M**	6.21	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**5**	0	0	0	0	**2**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Setotoma	Quthing	**M**	0.52	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**2**
Ha Setsena	Mohale's Hoek	**M**	13.91	4	0	0	1	1	0	0	0	0	**5**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Setsomi	Mohale's Hoek	**M**	0.11	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	1	1	**8**
Ha Setsoto	Quthing	**S**	0.58	1	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**5**	0	0	0	0	**1**
Ha Seturumane	Leribe	**M**	0.32	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Seutloali	Mokhotlong	**M**	4.25	2	0	0	1	1	0	0	0	0	**3**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Shale	Mohale's Hoek	**M**	1.17	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Shoaepane	Berea	**M**	4.92	2	0	0	0	0	0	0	0	0	**2**	0	0	2	2	**3**	0	0	0	0	**1**
Ha Shoaepane	Mafeteng	**M**	1.71	1	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Shoaepane	Quthing	**M**	3.35	1	0	0	1	1	0	0	0	0	**1**	0	0	1	1	**4**	0	0	0	0	**2**
Ha Simione	Mohale's Hoek	**M**	11.14	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**3**	0	0	0	0	**2**
Ha Soai	Maseru	**S**	0.73	1	0	0	0	0	0	0	1	1	**3**	0	0	1	1	**4**	0	0	0	0	**2**
Ha Soai	Maseru	**S**	0.38	1	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**5**	0	0	0	0	**2**
Ha Sofonia	Thaba-Tseka	**M**	0.41	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	0	0	**4**
Ha Soko	Mokhotlong	**M**	6.08	2	2	2	3	3	0	0	1	1	**8**	0	0	1	1	**9**	0	0	0	0	**1**
Ha Solokoe	Maseru	**M**	0.48	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Solomon	Mafeteng	**M**	0.69	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Sootho	Mohale's Hoek	**M**	2.56	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Sootho	Thaba-Tseka	**M**	10.74	3	0	0	0	0	0	0	1	1	**4**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Sootho	Quthing	**M**	0.57	1	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**8**	0	0	0	0	**1**
Ha Sootho	Thaba-Tseka	**M**	4.88	2	0	0	0	0	0	0	1	1	**1**	0	0	1	1	**9**	0	0	0	0	**1**
Ha Sotoane	Thaba-Tseka	**M**	23.46	7	0	0	0	0	0	0	1	1	**8**	0	0	0	0	**3**	0	0	0	0	**3**
Ha Souru	Quthing	**M**	23.63	7	0	0	1	1	0	0	1	1	**9**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Suoane	Mokhotlong	**M**	1.20	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	0	0	**3**
Ha Taaso	Berea	**M**	1.43	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**4**

Village Name	**District**	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Tabo	Thaba-Tseka	**M**	3.53	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Tabo	Berea	**M**	3.89	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**3**
Ha Taele	Butha-Buthe	**M**	0.33	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Taka	Maseru	**S**	0.98	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Takalimane	Mohale's Hoek	**M**	0.62	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Takalimane	Maseru	**M**	4.17	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Takane	Leribe	**S**	1.01	1	0	0	2	2	0	0	2	2	**6**	0	0	0	0	**1**	0	0	0	0	**3**
Ha Takatso	Maseru	**M**	2.35	1	0	0	0	0	0	0	0	0	**1**	1	2	0	0	**7**	0	0	0	0	**2**
Ha Tala	Thaba-Tseka	**M**	3.44	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Talimo	Qacha's Nek	**M**	15.39	5	0	0	0	0	0	0	1	1	**6**	0	0	0	0	**2**	0	0	1	1	**5**
Ha Tang	Quthing	**M**	3.13	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Tanka	Butha-Buthe	**M**	1.77	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	0	0	**4**
Ha Tankele	Mafeteng	**M**	2.58	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Taole	Mafeteng	**M**	2.28	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Tatolo	Mohale's Hoek	**M**	3.63	1	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**3**	0	0	0	0	**3**
Ha Tau	Maseru	**M**	2.91	1	0	0	0	0	0	0	1	1	**1**	0	0	8	8	**2**	0	0	0	0	**1**
Ha Tau	Maseru	**M**	2.56	1	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**10**	0	0	0	0	**1**
Ha Tauhali	Berea	**M**	2.29	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Taunyana	Leribe	**M**	5.68	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Tebaleti	Mohale's Hoek	**M**	1.89	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**0**	0	0	0	0	**1**
Ha Tebalo	Leribe	**M**	2.54	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**7**	0	0	0	0	**4**
Ha Tebatso	Berea	**M**	0.10	0	0	0	0	0	0	0	0	0	**0**	0	0	8	8	**11**	0	0	0	0	**1**
Ha Tebelo	Thaba-Tseka	**M**	23.31	7	0	0	0	0	0	0	0	0	**7**	0	0	8	8	**11**	0	0	0	0	**1**
Ha Teko	Leribe	**M**	10.98	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Telukhunoana	Mafeteng	**S**	0.25	1	0	0	1	1	0	0	1	1	**4**	0	0	8	8	**10**	0	0	0	0	**1**

Village Name	**District**	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Tenesolo	Maseru	**M**	0.48	1	0	0	0	0	0	0	0	0	**1**	0	0	8	8	**12**	0	0	0	0	**1**
Ha Tente	Berea	**M**	0.27	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Tetebela	Thaba-Tseka	**M**	7.37	2	0	0	3	3	0	0	1	1	**6**	0	0	8	8	**11**	0	0	0	0	**1**
Ha Teu	Leribe	**M**	1.77	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**4**
Ha Thaabe	Maseru	**M**	7.22	2	1	1	1	1	0	0	1	1	**5**	0	0	1	1	**3**	0	0	1	1	**7**
Ha Thaba	Mokhotlong	**M**	5.55	2	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**2**
Ha Thaba	Maseru	**M**	0.46	1	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**2**	0	0	0	0	**3**
Ha Thaba	Leribe	**M**	7.29	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**4**	0	0	0	0	**3**
Ha Thaba-Bosiu	Mohale's Hoek	**M**	1.69	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**5**	0	0	0	0	**1**
Ha Thabo	Qacha's Nek	**M**	8.07	3	0	0	0	0	0	0	1	1	**4**	0	0	1	1	**2**	0	0	0	0	**4**
Ha Thabo	Maseru	**M**	17.30	5	0	0	3	3	0	0	0	0	**8**	0	0	1	1	**2**	0	0	0	0	**4**
Ha Thabo Matete	Thaba-Tseka	**S**	0.09	0	0	0	1	1	0	0	1	1	**3**	0	0	1	1	**5**	0	0	0	0	**1**
Ha Thaha	Maseru	**M**	1.89	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**2**
Ha Thahanyane	Mohale's Hoek	**M**	11.79	4	0	0	0	0	0	0	1	1	**5**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Thakabanna	Quthing	**S**	0.23	1	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Thakhalle	Mafeteng	**M**	2.81	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Thamae	Mafeteng	**S**	0.24	1	0	0	3	3	0	0	3	3	**8**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Thebe	Mafeteng	**M**	3.84	2	0	0	1	1	0	0	0	0	**3**	0	0	1	1	**3**	0	0	0	0	**5**
Ha Thebe-ea-khale	Mafeteng	**M**	2.23	1	0	0	1	1	0	0	1	1	**3**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Thebesoa	Berea	**M**	0.32	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Theko	Thaba-Tseka	**M**	4.23	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**4**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Theko Bereng	Maseru	**M**	0.40	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Thetso	Leribe	**M**	0.26	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	0	0	**4**
Ha Thibella	Thaba-Tseka	**M**	6.50	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**9**	0	0	0	0	**2**
Ha Thoahlane	Mohale's Hoek	**M**	2.99	1	0	0	0	0	0	0	0	0	**1**	0	0	4	4	**6**	0	0	0	0	**1**
Ha Thoriso	Quthing	**M**	19.56	6	0	0	1	1	0	0	1	1	**8**	0	0	2	2	**4**	0	0	0	0	**1**
Ha Thotobolo	Mafeteng	**M**	6.22	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Thuhloane	Mohale's Hoek	**M**	2.53	1	0	0	1	1	0	0	1	1	**3**	0	0	1	1	**4**	0	0	0	0	**1**
Ha Tieho	Mokhotlong	**M**	5.97	2	0	0	0	0	0	0	1	1	**3**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Timpane	Berea	**M**	8.48	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**2**	0	0	0	0	**2**
Ha Tjama	Mohale's Hoek	**M**	2.65	1	0	0	0	0	0	0	1	1	**2**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Tjamela	Mohale's Hoek	**M**	1.06	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	0	0	**5**
Ha Tjoobe	Mohale's Hoek	**M**	2.28	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	0	0	**2**
Ha Tjootjo	Maseru	**M**	2.91	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**0**
Ha Tjopa	Mafeteng	**M**	1.58	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**3**	0	0	0	0	**2**
Ha Tlali	Mokhotlong	**M**	10.85	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Tlali	Maseru	**M**	4.36	2	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**5**	0	0	0	0	**1**
Ha Tlali	Thaba-Tseka	**M**	0.19	1	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**1**	0	0	0	0	**4**
Ha Tlali	Maseru	**S**	0.26	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**1**	0	0	1	1	**7**
Ha Tlalinyane	Quthing	**M**	7.57	3	0	0	1	1	0	0	0	0	**4**	0	0	1	1	**3**	0	0	1	1	**5**
Ha Tlebere	Maseru	**M**	2.64	1	0	0	1	1	0	0	0	0	**2**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Tlelase	Leribe	**S**	0.39	1	0	0	2	2	0	0	2	2	**6**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Tlhabeli	Maseru	**M**	0.37	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Tlhakanelo	Maseru	**M**	0.17	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Tlhaku	Mohale's Hoek	**S**	0.16	1	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Tlholo	Maseru	**M**	1.70	1	0	0	0	0	0	0	1	1	**2**	0	0	1	1	**3**	0	0	0	0	**1**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Tlhoro	Quthing	**M**	2.31	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**4**
Ha Tobolela	Leribe	**M**	0.57	1	0	0	1	1	0	0	0	0	**2**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Toka	Qacha's Nek	**M**	2.26	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**0**
Ha Tokelo	Leribe	**M**	0.94	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	0	0	**1**
Ha Tokho	Thaba-Tseka	**M**	0.96	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Toloane	Quthing	**M**	2.04	1	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**2**	0	0	0	0	**3**
Ha Tomo	Thaba-Tseka	**M**	2.22	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Topisi	Maseru	**M**	0.41	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Tsabalira	Butha-Buthe	**M**	10.37	3	0	0	1	1	0	0	0	0	**4**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Tsae	Leribe	**M**	0.16	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**5**
Ha Tsaeng	Leribe	**M**	3.41	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	1	1	**4**
Ha Tsapane	Leribe	**M**	0.55	1	0	0	0	0	0	0	0	0	**1**	3	6	0	0	**7**	0	0	0	0	**1**
Ha Tsautse	Mafeteng	**M**	4.83	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Tsekana	Maseru	**M**	1.81	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**5**
Ha Tsekelo	Maseru	**S**	0.05	0	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Tseko	Berea	**M**	3.09	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Tsepane	Mokhotlong	**M**	3.96	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**3**	0	0	0	0	**1**
Ha Tsepe	Quthing	**M**	7.97	3	0	0	0	0	0	0	1	1	**4**	0	0	0	0	**1**	0	0	0	0	**3**
Ha Tsepiso	Leribe	**M**	2.21	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Tsepo	Quthing	**M**	5.88	2	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**3**	0	0	0	0	**3**
Ha Tsese	Berea	**M**	7.95	3	0	0	0	0	0	0	1	1	**2**	0	0	1	1	**3**	0	0	0	0	**1**
Ha Tsese	Maseru	**M**	6.09	2	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**1**	0	0	0	0	**2**
Ha Tsese	Mohale's Hoek	**M**	3.69	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**3**	0	0	0	0	**3**
Ha Tsiame	Mokhotlong	**S**	0.44	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Tsiame	Berea	**M**	4.08	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**4**
Ha Tsiane	Maseru	**M**	0.87	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	0	0	**1**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Tsie	Maseru	**M**	11.42	4	0	0	0	0	0	0	1	1	**5**	0	0	0	0	**4**	0	0	0	0	**2**
Ha Tsilo	Mohale's Hoek	**M**	8.63	3	0	0	0	0	0	0	1	1	**4**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Tsilonyane	Maseru	**M**	5.44	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Tsita	Maseru	**M**	0.65	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**6**
Ha Tsiu	Qacha's Nek	**M**	3.70	1	0	0	0	0	0	0	1	1	**4**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Tsiu	Thaba-Tseka	**M**	4.06	2	0	0	3	3	0	0	1	1	**6**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Tsiu	Maseru	**M**	6.85	2	0	0	1	1	0	0	1	1	**1**	0	0	0	0	**1**	0	0	0	0	**2**
Ha Tsiu	Maseru	**M**	0.32	1	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**3**	0	0	0	0	**2**
Ha Tsiu	Thaba-Tseka	**M**	1.73	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	1	1	**3**
Ha Tsoarelo	Quthing	**M**	7.09	2	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**4**	0	0	0	0	**3**
Ha Tsoene	Thaba-Tseka	**M**	8.26	3	1	1	1	1	0	0	1	1	**6**	0	0	0	0	**6**	0	0	0	0	**1**
Ha Tsoene	Quthing	**M**	18.79	6	0	0	0	0	0	0	0	0	**6**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Tsoinyane	Qacha's Nek	**S**	0.59	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Tsolo	Maseru	**M**	3.92	2	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**5**	0	0	0	0	**4**
Ha Tsoloane	Mohale's Hoek	**M**	17.11	5	0	0	0	0	0	0	1	1	**6**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Tsomo	Mafeteng	**M**	5.59	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**3**
Ha Tsosane	Maseru	**M**	3.60	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**3**
Ha Tsutsulupao	Qacha's Nek	**M**	2.47	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**2**	0	0	0	0	**4**
Ha Tukoe	Maseru	**M**	0.19	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Tumahole	Maseru	**M**	0.98	1	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**1**
Ha Tumahole	Leribe	**M**	4.55	2	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Tumane	Maseru	**M**	3.16	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ha Tumo	Butha-Buthe	**M**	1.79	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	0	0	**1**
Ha Tumo	Mohale's Hoek	**M**	8.02	3	0	0	1	1	0	0	1	1	**1**	0	0	0	0	**2**	0	0	0	0	**2**
Ha Tumo	Mafeteng	**M**	3.63	1	0	0	0	0	0	0	0	0	**5**	0	0	0	0	**1**	0	0	0	0	**3**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ha Turupu	Mohale's Hoek	**M**	4.95	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**2**	0	0	0	0	**1**
Ha-Jontane	Mafeteng	**M**	3.52	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**3**	0	0	0	0	**2**
HaMofutho	Thaba-Tseka	**M**	3.48	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	1	1	**6**
Helehehle	Qacha's Nek	**M**	4.25	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**3**	0	0	0	0	**2**
Hermon (Patising)	Mafeteng	**M**	8.54	3	0	0	1	1	0	0	0	0	**4**	0	0	0	0	**1**	0	0	0	0	**2**
Hillside	Mafeteng	**M**	0.58	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	1	1	**3**
Hlabathe	Qacha's Nek	**M**	2.27	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**4**	0	0	0	0	**1**
Hlakoaneng	Maseru	**M**	3.58	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**5**
Hleoheng	Mafeteng	**M**	2.26	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**5**	0	0	0	0	**2**
Hloahloeng	Thaba-Tseka	**M**	6.02	2	1	1	1	1	0	0	0	0	**2**	0	0	0	0	**3**	0	0	0	0	**1**
Hloahloeng	Thaba-Tseka	**M**	6.99	2	0	0	0	0	0	0	0	0	**4**	0	0	0	0	**10**	0	0	0	0	**1**
Hohobeng	Mohale's Hoek	**M**	7.57	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**2**
Hombani	Mohale's Hoek	**M**	1.31	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Ihlo-Letso	Quthing	**M**	1.59	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**5**	0	0	0	0	**1**
Joala-Boholo	Mokhotlong	**M**	4.23	2	2	2	2	2	0	0	1	1	**7**	0	0	0	0	**2**	0	0	0	0	**1**
Joala-Boholo	Berea	**M**	3.75	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**2**
Jorotane Ha Makhobalo	Maseru	**M**	0.31	1	0	0	0	0	0	0	0	0	**1**	0	0	2	2	**4**	0	0	1	1	**6**
Kanana	Maseru	**M**	5.26	2	0	0	1	1	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Kanana	Qacha's Nek	**M**	0.54	1	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**1**
Kao (Shishila)	Mokhotlong	**S**	0.63	1	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**5**	0	0	0	0	**2**
Kerammele	Butha-Buthe	**M**	15.54	5	0	0	0	0	0	0	0	0	**5**	0	0	0	0	**2**	0	0	0	0	**1**
Kerekeng Ha Liau	Leribe	**M**	0.69	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	0	0	**2**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Ketane a Hlalele	Mohale's Hoek	**M**	13.49	4	0	0	1	1	0	0	0	0	**5**	0	0	0	0	**4**	0	0	0	0	**1**
Khafune	Maseru	**M**	13.80	4	0	0	0	0	0	0	0	0	**4**	0	0	0	0	**1**	0	0	0	0	**2**
Khakeng	Berea	**M**	2.45	1	0	0	0	0	0	0	0	0	**1**	1	2	0	0	**4**	0	0	0	0	**1**
Khakhathaneng	Quthing	**M**	5.27	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**5**	0	0	1	1	**6**
Khalong-la-Likhama	Mohale's Hoek	**M**	11.89	4	0	0	0	0	0	0	0	0	**4**	1	2	0	0	**5**	0	0	0	0	**4**
Khamane	Quthing	**M**	9.89	3	0	0	1	1	0	0	1	1	**5**	0	0	0	0	**9**	0	0	0	0	**1**
Khano Ha Rapholo	Butha-Buthe	**M**	0.44	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**4**
Khatleng	Berea	**M**	4.54	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**3**	0	0	0	0	**1**
Khilibithing	Maseru	**M**	9.87	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**4**	0	0	0	0	**1**
Khilibiting	Butha-Buthe	**M**	2.63	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	1	1	**4**
Khoaeleng	Mafeteng	**M**	6.20	2	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**3**	0	0	1	1	**6**
Khohlong	Thaba-Tseka	**M**	7.84	3	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**4**
Khohlong	Quthing	**M**	0.19	1	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**2**	0	0	0	0	**7**
Khohlong Ha Mofolo	Quthing	**M**	2.99	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**7**	0	0	1	1	**4**
Khohlo-Ntso	Qacha's Nek	**M**	11.84	4	0	0	1	1	0	0	1	1	**6**	0	0	2	2	**4**	0	0	0	0	**7**
Khokhoba Ha Lebese	Thaba-Tseka	**M**	0.34	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Khokhotsaneng	Berea	**M**	2.87	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	1	1	**5**
Kholekoe	Maseru	**M**	2.33	1	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**1**	0	0	1	1	**4**
Kholoaneng	Maseru	**M**	0.61	1	0	0	0	0	0	0	0	0	**1**	0	0	2	2	**3**	0	0	1	1	**6**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Kholokoe	Mokhotlong	**M**	2.55	1	0	0	1	1	0	0	1	1	**3**	0	0	2	2	**5**	0	0	0	0	**1**
Kholokoe	Thaba-Tseka	**M**	10.95	3	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**4**	0	0	1	1	**4**
Kholokoe	Mokhotlong	**M**	5.36	2	0	0	0	0	0	0	0	0	**4**	0	0	2	2	**2**	0	0	1	1	**6**
Kholokoe 'Mathata	Mafeteng	**M**	0.60	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	1	1	**2**
Khololikane	Leribe	**M**	1.40	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**4**
Khomoea-Mollo	Maseru	**S**	0.65	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**5**	0	0	0	0	**2**
Khomo-li-iteng	Thaba-Tseka	**M**	16.43	5	0	0	0	0	0	0	0	0	**5**	0	0	2	2	**5**	0	0	1	1	**3**
Khomong Ha Scout	Thaba-Tseka	**M**	0.31	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Khonofaneng	Mohale's Hoek	**M**	2.77	1	0	0	0	0	0	0	0	0	**1**	0	0	2	2	**10**	0	0	1	1	**7**
Khopung	Mokhotlong	**M**	14.25	4	2	2	3	3	0	0	0	0	**9**	0	0	0	0	**1**	0	0	1	1	**4**
Khoro-e-Betloa	Leribe	**M**	2.97	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	1	1	**4**
Khorong Ha Mantsa	Mohale's Hoek	**M**	5.11	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**8**
Khorong Ha Nchela	Maseru	**S**	0.43	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**1**	0	0	0	0	**7**
Khorong Ha Sephooko	Berea	**M**	0.35	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**4**
Khoshaneng	Thaba-Tseka	**S**	0.25	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**7**	0	0	1	1	**6**
Khotojieng	Thaba-Tseka	**M**	18.46	5	0	0	0	0	0	0	0	0	**5**	0	0	0	0	**3**	0	0	1	1	**9**
Khubetsoana	Thaba-Tseka	**M**	8.39	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**2**	0	0	1	1	**4**
Khukhune	Maseru	**S**	0.24	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**2**	0	0	1	1	**4**
Khumamela Ha Lekunutu	Mokhotlong	**M**	5.07	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**1**	0	0	1	1	**5**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Khutlo-Peli	Maseru	**S**	0.31	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**2**	0	0	1	1	**3**
Kobong Ha Mallane	Mokhotlong	**M**	7.26	2	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**2**	0	0	1	1	**4**
Koeneng	Leribe	**M**	4.24	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**3**
Koeneng	Thaba-Tseka	**M**	7.22	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	1	1	**4**
Koeneng	Thaba-Tseka	**M**	0.96	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	1	1	**6**
Kokobe	Berea	**M**	12.74	4	0	0	1	1	0	0	0	0	**5**	0	0	0	0	**3**	0	0	0	0	**4**
Kolojane Ha Seisa	Leribe	**M**	10.52	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**3**	0	0	0	0	**4**
Koma-Koma	Berea	**M**	10.23	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**4**	0	0	1	1	**4**
Koma-Koma	Mokhotlong	**M**	4.26	2	0	0	0	0	0	0	0	0	**2**	0	0	5	5	**7**	0	0	1	1	**4**
Koma-Koma	Thaba-Tseka	**M**	5.51	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**3**	0	0	1	1	**6**
Kopanong	Berea	**M**	1.02	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**9**
Kopanong Ha Ntsie	Mafeteng	**M**	2.47	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	1	1	**2**
Kopialla	Quthing	**S**	0.78	1	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**4**	0	0	0	0	**3**
Kosheteng	Butha-Buthe	**M**	3.87	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**4**	0	0	1	1	**4**
Koting-sa-Mofao	Mokhotlong	**M**	9.30	3	0	0	0	0	0	0	1	1	**4**	0	0	1	1	**5**	0	0	0	0	**3**
Kotola	Thaba-Tseka	**M**	8.18	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**4**	0	0	1	1	**4**
Koung	Leribe	**M**	8.25	3	0	0	0	0	0	0	0	0	**4**	0	0	0	0	**4**	0	0	0	0	**2**
Koung	Maseru	**M**	4.63	2	0	0	1	1	0	0	1	1	**3**	0	0	1	1	**2**	0	0	0	0	**4**
Koung Ha Letele	Quthing	**M**	7.24	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**4**	0	0	1	1	**5**
Koung Phola Ha Phohla	Berea	**M**	0.47	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	1	1	**4**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Kubung	Mokhotlong	**M**	3.18	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	0	0	**4**
Kutung	Quthing	**M**	8.85	3	0	0	1	1	0	0	1	1	**5**	0	0	1	1	**3**	0	0	1	1	**5**
Lebakeng Ha Molomo	Leribe	**M**	4.51	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**6**	0	0	1	1	**4**
Lehahaneng	Qacha's Nek	**M**	16.03	5	0	0	1	1	0	0	0	0	**6**	0	0	1	1	**3**	0	0	1	1	**7**
Lehlakaneng	Mafeteng	**S**	0.65	1	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**6**	0	0	0	0	**1**
Lehlakaneng	Butha-Buthe	**M**	11.69	4	0	0	1	1	0	0	0	0	**5**	0	0	1	1	**3**	0	0	1	1	**8**
Lehloara	Thaba-Tseka	**M**	7.22	2	0	0	0	0	0	0	1	1	**3**	0	0	1	1	**5**	0	0	0	0	**4**
Lehlohonolong	Butha-Buthe	**M**	12.95	4	0	0	1	1	0	0	0	0	**5**	0	0	1	1	**3**	0	0	1	1	**4**
Lejoemotho	Mohale's Hoek	**M**	0.17	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	1	1	**3**
Lekhalong	Leribe	**M**	5.65	2	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**2**	0	0	1	1	**3**
Lekhalong	Berea	**M**	1.52	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	1	1	**3**
Lekhalong	Mafeteng	**M**	0.55	1	0	0	0	0	0	0	0	0	**4**	0	0	1	1	**2**	0	0	1	1	**5**
Lekhalong	Leribe	**M**	4.86	2	0	0	1	1	0	0	1	1	**1**	0	0	1	1	**3**	0	0	1	1	**7**
Lekhalong Ha Sekepe	Mohale's Hoek	**M**	1.88	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**5**	0	0	1	1	**4**
Lekoro		**M**	7.85	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**1**	0	0	1	1	**5**
Lentsoaneng	Quthing	**M**	2.56	1	0	0	1	1	0	0	1	1	**3**	0	0	1	1	**2**	0	0	1	1	**4**
Lentsoeteng	Leribe	**M**	2.81	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**5**	0	0	1	1	**4**
Lenyakoane	Mokhotlong	**M**	10.08	3	0	0	1	1	0	0	1	1	**5**	0	0	1	1	**3**	0	0	1	1	**5**
Lepapaneng	Leribe	**M**	6.64	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**3**	0	0	1	1	**3**
Lepaqoa	Qacha's Nek	**M**	7.47	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**2**	0	0	1	1	**4**
Lephal	Leribe	**M**	3.04	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	1	1	**4**
Leqhekoana Ha Makopoi	Thaba-Tseka	**M**	9.77	3	0	0	0	0	0	0	1	1	**4**	0	0	1	1	**2**	0	0	1	1	**5**
Leralleng	Thaba-Tseka	**M**	2.17	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**2**	0	0	1	1	**4**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Leribe	Maseru	**M**	0.39	1	0	0	0	0	0	0	0	0	**1**	0	0	8	8	**13**	0	0	0	0	**1**
Leribe	Thaba-Tseka	**M**	13.47	4	0	0	0	0	0	0	1	1	**5**	0	0	0	0	**1**	0	0	1	1	**4**
Leropong	Mohale's Hoek	**M**	2.65	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Leseling Ha Tjetja	Maseru	**M**	11.23	3	1	1	1	1	0	0	0	0	**5**	0	0	0	0	**4**	0	0	1	1	**3**
Letlaneng	Qacha's Nek	**M**	10.25	3	0	0	1	1	0	0	0	0	**4**	0	0	1	1	**2**	0	0	1	1	**4**
Letlapeng	Mohale's Hoek	**M**	1.36	1	0	0	0	0	0	0	0	0	**1**	0	0	8	8	**10**	0	0	1	1	**2**
Letlapeng	Maseru	**M**	3.07	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**5**	0	0	1	1	**4**
Letlapeng	Mohale's Hoek	**M**	15.59	5	0	0	1	1	0	0	1	1	**7**	0	0	8	8	**10**	0	0	1	1	**4**
Letlapeng	Maseru	**M**	0.35	1	0	0	0	0	0	0	0	0	**1**	0	0	8	8	**11**	0	0	0	0	**6**
Letseng	Mohale's Hoek	**M**	3.45	1	0	0	0	0	0	0	0	0	**1**	1	2	8	8	**15**	0	0	1	1	**5**
Letseng-la-Terae	Mokhotlong	**M**	17.71	5	0	0	0	0	0	0	1	1	**6**	2	4	8	8	**16**	0	0	0	0	**2**
Letsunyane Ha Mphafolane	Maseru	**M**	2.05	1	0	0	1	1	0	0	0	0	**2**	0	0	8	8	**10**	0	0	1	1	**5**
Levi's Nek	Leribe	**M**	0.69	1	0	0	2	2	0	0	0	0	**3**	0	0	1	1	**3**	0	0	1	1	**7**
Lexeni	Quthing	**M**	2.50	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	1	1	**4**
Libibing	Mokhotlong	**M**	0.12	1	0	0	0	0	0	0	0	0	**1**	0	0	8	8	**10**	0	0	1	1	**4**
Libobeng	Qacha's Nek	**M**	20.60	6	0	0	0	0	0	0	0	0	**6**	0	0	1	1	**8**	0	0	1	1	**4**
Liboping	Berea	**M**	0.13	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	1	1	**4**
Liboping	Leribe	**M**	0.36	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	1	1	**4**
Lichecheng	Mokhotlong	**M**	5.67	2	2	2	3	3	0	0	1	1	**4**	0	0	0	0	**1**	0	0	1	1	**3**
Lichecheng	Quthing	**S**	0.71	1	0	0	1	1	0	0	1	1	**8**	0	0	0	0	**6**	0	0	1	1	**6**
Lichecheng	Maseru	**M**	3.84	2	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**2**	0	0	1	1	**7**
Lifajaneng	Mafeteng	**M**	5.85	2	0	0	1	1	0	0	3	3	**6**	0	0	0	0	**4**	0	0	1	1	**4**
Lifefong	Butha-Buthe	**M**	0.11	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Lihlabeng	Mokhotlong	**M**	5.02	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**3**	0	0	1	1	**6**
Lihloaeleng	Thaba-Tseka	**M**	0.25	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**6**
Lihloahloeng	Thaba-Tseka	**M**	5.50	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	1	1	**8**
Lihlookong	Mafeteng	**M**	1.04	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	1	1	**2**
Likhahleng	Butha-Buthe	**M**	1.22	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**3**
Likhakeng	Mohale's Hoek	**M**	0.36	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**5**
Likhaleng	Butha-Buthe	**M**	4.05	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	1	1	**4**
Likhama Ha Ntinisi	Thaba-Tseka	**M**	11.65	4	0	0	1	1	0	0	1	1	**6**	0	0	0	0	**4**	0	0	1	1	**3**
Likhameng	Mokhotlong	**M**	5.91	2	0	0	0	0	0	0	0	0	**2**	1	2	1	1	**8**	0	0	1	1	**3**
Likhameng	Qacha's Nek	**M**	3.03	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**1**	0	0	1	1	**5**
Likhameng	Maseru	**M**	7.23	2	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**3**	0	0	1	1	**5**
Likhang	Mokhotlong	**M**	15.78	5	0	0	0	0	0	0	0	0	**5**	0	0	1	1	**6**	0	0	1	1	**4**
Likhetleng	Mafeteng	**M**	2.71	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**3**
Likhoaleng	Qacha's Nek	**M**	2.02	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**4**	0	0	1	1	**6**
Likhohloaneng	Qacha's Nek	**M**	1.17	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	1	1	**3**
Likhutloaneng	Mohale's Hoek	**M**	10.16	3	0	0	0	0	0	0	1	1	**4**	0	0	1	1	**5**	0	0	1	1	**4**
Likhutlong Ha Phallang	Maseru	**M**	2.77	1	0	0	1	1	0	0	1	1	**3**	0	0	3	3	**6**	0	0	1	1	**4**
Likhutlong'Mak'holo	Berea	**M**	9.03	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**3**	0	0	1	1	**5**
Likileng	Qacha's Nek	**M**	4.52	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	1	1	**4**
Likoae	Mokhotlong	**M**	2.40	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	1	1	**5**
Likoekoeng	Mokhotlong	**M**	19.59	6	0	0	0	0	0	0	0	0	**6**	0	0	1	1	**7**	0	0	1	1	**4**
Likolobeng	Quthing	**M**	6.66	2	0	0	1	1	0	0	0	0	**3**	0	0	1	1	**3**	0	0	0	0	**6**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Likolobeng Ha Japi	Maseru	**S**	0.50	1	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**3**	0	0	1	1	**7**
Likomeng	Thaba-Tseka	**M**	9.17	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**4**	0	0	1	1	**3**
Likonyeleng	Qacha's Nek	**M**	3.33	1	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**1**	0	0	1	1	**9**
Likorolo Ha Elia	Maseru	**M**	0.15	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**3**
Likotase	Qacha's Nek	**M**	9.51	3	0	0	1	1	0	0	1	1	**5**	0	0	0	0	**3**	0	0	0	0	**5**
Likoting	Mokhotlong	**M**	4.82	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**3**	0	0	1	1	**6**
Likotopong Ha Pisto	Maseru	**M**	1.95	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**1**	0	0	1	1	**3**
Likoung	Thaba-Tseka	**M**	11.08	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**4**	0	0	1	1	**5**
Lilomong	Thaba-Tseka	**M**	0.67	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	1	1	**6**
Limapong	Mafeteng	**M**	16.42	5	0	0	0	0	0	0	1	1	**6**	0	0	1	1	**6**	0	0	0	0	**1**
Limapong	Mokhotlong	**M**	3.07	1	0	0	1	1	0	0	1	1	**3**	0	0	8	8	**11**	0	0	0	0	**7**
Limonkaneng	Mokhotlong	**M**	12.66	4	1	1	1	1	0	0	0	0	**6**	0	0	0	0	**7**	0	0	1	1	**6**
Linakeng	Thaba-Tseka	**M**	0.48	1	0	0	1	1	0	0	0	0	**2**	0	0	1	1	**3**	0	0	0	0	**7**
Linakeng Ha Rapase	Qacha's Nek	**M**	3.81	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**2**	0	0	1	1	**4**
Linakotseng	Maseru	**M**	1.04	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**3**
Linareng	Mokhotlong	**M**	12.83	4	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**4**	0	0	0	0	**1**
Linareng	Mokhotlong	**M**	20.75	6	0	0	0	0	0	0	0	0	**5**	0	0	0	0	**4**	0	0	0	0	**1**
Linareng	Mokhotlong	**M**	2.71	1	0	0	0	0	0	0	0	0	**6**	0	0	0	0	**6**	0	0	1	1	**2**
Linareng	Mohale's Hoek	**M**	4.16	2	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**1**	0	0	0	0	**4**
Lingoareng	Thaba-Tseka	**M**	0.30	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	2	2	**5**
Linyookong	Leribe	**M**	18.02	5	0	0	0	0	0	0	1	1	**6**	0	0	0	0	**5**	0	0	1	1	**4**
Liokhoane	Mokhotlong	**M**	5.77	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**4**	0	0	1	1	**3**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Liotloaneng	Mokhotlong	**M**	9.49	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**4**	0	0	1	1	**4**
Lipelong Ha Soloja	Qacha's Nek	**M**	4.60	2	0	0	1	1	0	0	1	1	**4**	1	2	0	0	**6**	0	0	1	1	**5**
Liphakoeng	Thaba-Tseka	**M**	1.02	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	1	1	**3**
Liphakoeng	Butha-Buthe	**S**	0.75	1	0	0	0	0	0	0	1	1	**1**	0	0	1	1	**2**	0	0	1	1	**4**
Liphakoeng	Thaba-Tseka	**M**	1.14	1	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**5**	0	0	1	1	**5**
Liphakoeng	Mokhotlong	**M**	4.57	2	0	0	0	0	0	0	1	1	**3**	0	0	3	3	**3**	0	0	1	1	**6**
Liphaleng	Leribe	**M**	1.48	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**5**	0	0	1	1	**9**
Liphamoleng	Mohale's Hoek	**M**	10.57	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**4**	0	0	1	1	**3**
Liphiring		**M**	3.42	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	1	1	**5**
Liphiring	Berea	**M**	0.56	1	0	0	0	0	0	0	0	0	**1**	0	0	2	2	**2**	0	0	1	1	**6**
Liphookoaneng	Thaba-Tseka	**S**	0.32	1	0	0	0	0	0	0	1	1	**2**	0	0	3	3	**10**	0	0	1	1	**4**
Liphookoaneng	Berea	**M**	2.94	1	0	0	1	1	0	0	0	0	**3**	0	0	8	8	**5**	0	0	0	0	**6**
Liptjemptjeteng	Mafeteng	**M**	2.88	1	0	0	0	0	0	0	0	0	**1**	0	0	8	8	**10**	0	0	1	1	**3**
Lipululeng	Mokhotlong	**M**	2.45	1	0	0	0	0	0	0	1	1	**2**	0	0	2	2	**5**	0	0	1	1	**6**
Liqala	Quthing	**M**	5.32	2	0	0	0	0	0	0	1	1	**3**	0	0	8	8	**12**	0	0	1	1	**6**
Liqalabeng	Qacha's Nek	**M**	6.54	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**3**	0	0	0	0	**1**
Liqalabeng	Qacha's Nek	**M**	1.39	1	0	0	0	0	0	0	1	1	**2**	0	0	8	8	**10**	0	0	1	1	**4**
Liqalaneng	Butha-Buthe	**M**	11.52	4	0	0	1	1	0	0	0	0	**5**	0	0	8	8	**13**	0	0	0	0	**3**
Liqaleng	Thaba-Tseka	**M**	19.39	6	0	0	0	0	0	0	0	0	**6**	0	0	2	2	**8**	0	0	1	1	**4**
Liqhobong	Butha-Buthe	**M**	14.60	4	0	0	1	1	0	0	0	0	**5**	0	0	1	1	**5**	0	0	0	0	**2**
Liqoabing	Maseru	**M**	1.67	1	0	0	0	0	0	0	0	0	**1**	0	0	8	8	**10**	0	0	1	1	**4**
Liqobong	Butha-Buthe	**M**	1.75	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	1	1	**6**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Liraoeleng	Mokhotlong	**M**	1.42	1	0	0	1	1	0	0	1	1	**3**	0	0	3	3	**5**	0	0	0	0	**1**
Liratsoaneng	Quthing	**M**	3.38	1	0	0	0	0	0	0	1	1	**2**	0	0	1	1	**3**	0	0	0	0	**1**
Lisaleng	Mokhotlong	**M**	8.45	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**4**	0	0	1	1	**4**
Liseleng Ha Hlolo	Mokhotlong	**M**	7.79	3	0	0	0	0	0	0	1	1	**4**	0	0	1	1	**4**	0	0	1	1	**7**
Liteleng	Butha-Buthe	**M**	15.60	5	4	4	3	3	0	0	0	0	**12**	0	0	3	3	**15**	0	0	0	0	**3**
Lithabaneng	Mafeteng	**M**	0.20	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	1	1	**4**
Lithakaling	Mohale's Hoek	**M**	4.68	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**3**	0	0	1	1	**8**
Lithakong	Thaba-Tseka	**M**	14.00	4	0	0	0	0	0	0	0	0	**4**	0	0	8	8	**13**	0	0	0	0	**2**
Lithakong	Qacha's Nek	**M**	1.28	1	0	0	1	1	0	0	1	1	**3**	0	0	8	8	**10**	0	0	1	1	**3**
Lithipeng	Mohale's Hoek	**M**	0.19	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	1	1	**9**
Lithotaneng	Thaba-Tseka	**M**	9.32	3	0	0	0	0	0	0	1	1	**4**	0	0	0	0	**3**	0	0	1	1	**7**
Litlhokoaneng	Leribe	**M**	3.48	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	0	0	**1**
Litsaaneng	Maseru	**M**	2.28	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**1**
Litsilong	Berea	**M**	4.27	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**2**	0	0	0	0	**2**
Litsoeneng Ha Tlokotsi	Quthing	**M**	8.63	3	0	0	1	1	0	0	1	1	**5**	0	0	1	1	**4**	0	0	1	1	**3**
Litsokeleng	Mafeteng	**S**	0.91	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**1**	0	0	0	0	**7**
Livovong	Quthing	**M**	9.79	3	0	0	0	0	0	0	1	1	**4**	1	2	1	1	**6**	0	0	1	1	**4**
Lulang	Thaba-Tseka	**M**	7.86	3	0	0	0	0	0	0	1	1	**4**	0	0	0	0	**3**	0	0	0	0	**2**
Lumang	Thaba-Tseka	**M**	9.59	3	0	0	0	0	0	0	1	1	**4**	0	0	0	0	**3**	0	0	1	1	**8**
Mabakaletsa	Mokhotlong	**M**	6.47	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	1	1	**3**
Mabalane	Butha-Buthe	**M**	2.58	1	0	0	0	0	0	0	0	0	**1**	0	0	8	8	**16**	0	0	1	1	**3**
Mabeleteng	Thaba-Tseka	**M**	0.45	1	0	0	0	0	0	0	0	0	**1**	0	0	8	8	**10**	0	0	1	1	**4**
Maboloka	Mohale's Hoek	**M**	0.93	1	0	0	0	0	0	0	0	0	**1**	0	0	8	8	**10**	0	0	1	1	**4**
Maboneng	Quthing	**M**	9.79	3	0	0	0	0	0	0	0	0	**3**	0	0	8	8	**10**	0	0	0	0	**5**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Mabuleng	Mokhotlong	**M**	10.93	3	0	0	0	0	0	0	1	1	**1**	0	0	1	1	**4**	0	0	1	1	**3**
Mabuleng	Mafeteng	**M**	2.66	1	0	0	0	0	0	0	0	0	**4**	0	0	1	1	**5**	0	0	1	1	**3**
Machafeela	Thaba-Tseka	**S**	0.54	1	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**2**	0	0	0	0	**1**
Macheseng Ha Rakokotsi	Mohale's Hoek	**M**	0.36	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	1	1	**3**
Mafika-Lisiu	Qacha's Nek	**M**	3.51	1	0	0	1	1	0	0	1	1	**3**	0	0	8	8	**3**	0	0	0	0	**1**
Mafika-Lisiu	Butha-Buthe	**M**	6.14	2	0	0	0	0	0	0	1	1	**3**	0	0	1	1	**11**	0	0	0	0	**1**
Mafika-Lisiu	Maseru	**M**	3.63	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	1	1	**3**
Mafika-Lisru	Berea	**M**	4.64	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**2**	0	0	1	1	**5**
Mafotholeng	Mokhotlong	**M**	13.99	4	1	1	1	1	0	0	0	0	**6**	0	0	0	0	**2**	0	0	0	0	**5**
Mafura-Pela	Mohale's Hoek	**M**	3.75	1	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**6**	0	0	0	0	**1**
Mahahaneng	Thaba-Tseka	**M**	8.30	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**3**	0	0	0	0	**1**
Mahahleng	Mokhotlong	**M**	2.89	1	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**3**	0	0	1	1	**4**
Mahemeng	Leribe	**M**	0.21	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Mahlabatheng	Maseru	**M**	0.47	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Mahlabatheng	Quthing	**M**	9.19	3	0	0	1	1	0	0	1	1	**5**	0	0	0	0	**2**	0	0	1	1	**2**
Mahlachaneng	Mafeteng	**M**	3.51	1	0	0	0	0	0	0	1	1	**2**	0	0	1	1	**4**	0	0	1	1	**3**
Mahlakeng	Mohale's Hoek	**M**	6.85	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**2**	0	0	1	1	**2**
Mahlalela	Maseru	**M**	0.98	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Mahloenyeng Ha Petje	Thaba-Tseka	**M**	2.93	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**2**
Maholoka	Mafeteng	**M**	3.84	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**9**	0	0	0	0	**2**
Maholokoana	Berea	**M**	3.02	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**5**
Maholong	Mafeteng	**M**	4.56	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**1**	0	0	1	1	**4**
Maholong	Thaba-Tseka	**M**	4.03	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	1	1	**4**
Mahooeng	Thaba-Tseka	**M**	9.05	3	0	0	0	0	0	0	1	1	**4**	0	0	0	0	**5**	0	0	0	0	**3**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Mahuleng	Maseru	**M**	0.36	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	0	0	**1**
Mahuu	Berea	**M**	0.70	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Majaheng	Mohale's Hoek	**M**	0.48	1	0	0	0	0	0	0	0	0	**1**	0	0	8	8	**11**	0	0	1	1	**4**
Majakaneng	Butha-Buthe	**M**	1.56	1	0	0	0	0	0	0	0	0	**6**	0	0	0	0	**1**	0	0	0	0	**1**
Majakaneng	Mohale's Hoek	**M**	15.05	5	0	0	0	0	0	0	1	1	**1**	0	0	0	0	**1**	0	0	0	0	**6**
Majapereng	Maseru	**M**	0.83	1	0	0	0	0	0	0	0	0	**4**	0	0	0	0	**1**	0	0	0	0	**1**
Majapereng		**M**	4.99	2	0	0	1	1	0	0	1	1	**1**	0	0	0	0	**6**	0	0	0	0	**1**
Majekeng	Berea	**M**	2.13	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**4**
Majoe-Matso	Maseru	**M**	2.01	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**4**
Majoe-Matso Ha Phalole	Quthing	**M**	4.30	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**1**
Majuping	Mohale's Hoek	**M**	5.00	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**1**
Makahalaneng	Leribe	**M**	0.89	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	0	0	**4**
Makakamela	Qacha's Nek	**S**	0.12	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**1**	0	0	0	0	**1**
Makanyane Ha Malefane	Thaba-Tseka	**M**	2.79	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**3**
Makanyaneng	Butha-Buthe	**M**	0.10	0	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**0**	0	0	1	1	**1**
Makanyaneng	Quthing	**M**	3.05	1	0	0	1	1	0	0	1	1	**0**	0	0	0	0	**2**	0	0	0	0	**4**
Makatikele	Quthing	**S**	0.24	1	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**2**	0	0	0	0	**0**
Makatseng	Mafeteng	**M**	2.72	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Makaung	Butha-Buthe	**M**	0.51	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**2**
Makeneng	Maseru	**M**	0.81	1	0	0	0	0	0	0	0	0	**0**	0	0	0	0	**1**	0	0	1	1	**1**
Makeneng	Butha-Buthe	**M**	1.85	1	0	0	1	1	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**3**
Makeneng	Mohale's Hoek	**M**	0.07	0	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**3**	0	0	0	0	**3**
Makhaleng	Qacha's Nek	**M**	5.58	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**0**	0	0	1	1	**4**
Makhalong	Thaba-Tseka	**M**	7.13	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**3**	0	0	1	1	**1**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Makhalong	Thaba-Tseka	**M**	10.05	3	0	0	1	1	0	0	0	0	**4**	0	0	0	0	**2**	0	0	1	1	**3**
Makhalong	Thaba-Tseka	**M**	1.18	1	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**3**	0	0	0	0	**3**
Makhalong	Quthing	**M**	3.72	1	0	0	1	1	0	0	0	0	**2**	0	0	1	1	**2**	0	0	1	1	**4**
Makhalong	Berea	**M**	8.70	3	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**2**	0	0	0	0	**7**
Mak'hamfolei	Berea	**M**	2.66	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	1	1	**2**
Mak'hamfolei	Mafeteng	**M**	5.09	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**2**	0	0	1	1	**3**
Makhanyeng	Mokhotlong	**M**	6.33	2	0	0	0	0	0	0	1	1	**3**	0	0	1	1	**4**	0	0	0	0	**1**
Makhapung	Thaba-Tseka	**M**	1.34	1	0	0	1	1	0	0	1	1	**3**	0	0	1	1	**4**	0	0	0	0	**1**
Makhapung	Mokhotlong	**M**	6.21	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**3**
Makhapung	Thaba-Tseka	**M**	12.26	4	0	0	0	0	0	0	0	0	**4**	0	0	0	0	**2**	0	0	1	1	**3**
Makheka Ha Mankere	Mafeteng	**M**	4.55	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**5**	0	0	1	1	**4**
Makhemeng	Mokhotlong	**M**	7.32	2	1	1	2	2	0	0	1	1	**6**	0	0	0	0	**2**	0	0	0	0	**5**
Makherehloa	Mohale's Hoek	**M**	5.31	2	0	0	0	0	0	0	1	1	**3**	1	2	0	0	**7**	0	0	0	0	**6**
Makhessuoeng	Quthing	**M**	0.43	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	1	1	**4**
Makhetheng	Mafeteng	**M**	9.35	3	0	0	1	1	0	0	0	0	**6**	0	0	0	0	**11**	0	0	0	0	**1**
Makhetheng	Quthing	**M**	8.22	3	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**6**	0	0	0	0	**3**
Makhetheng	Quthing	**M**	11.98	4	0	0	0	0	0	0	2	2	**4**	0	0	0	0	**1**	0	0	0	0	**4**
Makhetheng	Quthing	**M**	4.87	2	0	0	1	1	0	0	0	0	**5**	0	0	1	1	**3**	0	0	1	1	**6**
Makhetheng Ha Lesholu	Mohale's Hoek	**M**	0.41	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**1**
Makhine	Mafeteng	**M**	4.60	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**2**	0	0	1	1	**3**
Makhoaba Ha Lengolo	Mohale's Hoek	**M**	14.14	4	0	0	0	0	0	0	0	0	**4**	0	0	1	1	**3**	0	0	0	0	**1**
Makhoaeleng	Maseru	**M**	1.05	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**5**	0	0	1	1	**5**

Village Name	**District**	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Makhoakhoeng	Mokhotlong	**M**	0.52	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	0	0	**2**
Makhoarane	Qacha's Nek	**M**	1.99	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	1	1	**4**
Makhoareng	Thaba-Tseka	**M**	10.23	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**3**
Makhoatsing	Thaba-Tseka	**M**	8.69	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**3**	0	0	1	1	**3**
Makhuleng	Mohale's Hoek	**M**	0.53	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	1	1	**3**
Makilanyaneng	Leribe	**M**	17.46	5	0	0	0	0	0	0	0	0	**5**	0	0	1	1	**3**	0	0	1	1	**3**
Makoabating	Thaba-Tseka	**M**	5.77	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**5**	0	0	0	0	**1**
Makoabating	Mohale's Hoek	**M**	16.88	5	0	0	0	0	0	0	1	1	**6**	0	0	0	0	**3**	0	0	1	1	**3**
Makoaeleng	Butha-Buthe	**M**	3.20	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**5**	0	0	1	1	**3**
Makoeteng	Mokhotlong	**M**	10.84	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**2**	0	0	0	0	**1**
Makokoaneng	Mohale's Hoek	**M**	11.89	4	0	0	0	0	0	0	1	1	**5**	0	0	1	1	**4**	0	0	1	1	**3**
Makokong	Maseru	**M**	10.23	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**4**	0	0	1	1	**3**
Makokong Ha Abele	Mafeteng	**M**	0.48	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	1	1	**4**
Makokotoaneng	Butha-Buthe	**M**	0.32	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**2**
Makong	Leribe	**M**	2.84	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Makong	Mokhotlong	**M**	0.41	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**2**
Makopanong	Thaba-Tseka	**M**	0.60	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**8**
Makunyapane	Mohale's Hoek	**M**	3.15	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**7**
Makutoaneng	Mafeteng	**M**	6.59	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	1	1	**5**
Malaleng	Mafeteng	**S**	0.32	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**2**	0	0	0	0	**1**
Malealea	Leribe	**M**	2.84	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**4**
Maliba-Matso	Mohale's Hoek	**S**	0.24	1	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**2**	0	0	0	0	**7**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
'Malifatjana Ha Seele	Maseru	**M**	0.66	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**3**
Malimon	Mafeteng	**M**	4.40	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**5**
Malimong	Mohale's Hoek	**M**	4.37	2	0	0	1	1	0	0	1	1	**2**	0	0	0	0	**1**	0	0	0	0	**1**
Malimong	Qacha's Nek	**M**	0.13	1	0	0	0	0	0	0	0	0	**4**	0	0	0	0	**2**	0	0	1	1	**1**
Malimong	Thaba-Tseka	**M**	0.49	1	0	0	1	1	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**7**
Maliphofu Ha Letuka	Mohale's Hoek	**S**	0.37	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**1**	0	0	0	0	**1**
Maloreng	Quthing	**M**	8.23	3	0	0	1	1	0	0	1	1	**5**	0	0	0	0	**1**	0	0	0	0	**1**
Malosong	Thaba-Tseka	**M**	10.57	3	0	0	0	0	0	0	1	1	**4**	0	0	0	0	**4**	0	0	1	1	**2**
Malothoaneng	Maseru	**M**	9.83	3	0	0	1	1	0	0	0	0	**4**	0	0	0	0	**3**	0	0	0	0	**6**
Malumeleng	Mafeteng	**M**	5.39	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**3**	0	0	1	1	**7**
Malumeng	Mafeteng	**M**	8.52	3	0	0	1	1	0	0	1	1	**5**	0	0	0	0	**2**	0	0	0	0	**6**
'Mamokhorong	Thaba-Tseka	**M**	12.25	4	0	0	1	1	0	0	1	1	**6**	1	2	0	0	**5**	0	0	0	0	**1**
Manamaneng	Quthing	**M**	0.50	1	0	0	2	2	0	0	0	0	**3**	0	0	1	1	**5**	0	0	1	1	**4**
Manekoleng	Qacha's Nek	**M**	1.52	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	1	1	**4**
Manganeng	Mokhotlong	**M**	15.03	5	0	0	1	1	0	0	0	0	**5**	0	0	0	0	**6**	0	0	1	1	**1**
Manganeng	Mokhotlong	**M**	18.33	5	0	0	0	0	0	0	0	0	**6**	0	0	1	1	**1**	0	0	0	0	**2**
Mangaung	Butha-Buthe	**M**	2.35	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**5**	0	0	1	1	**4**
Manoeleng	Thaba-Tseka	**M**	8.63	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**1**	0	0	1	1	**6**
Mantsaneng	Thaba-Tseka	**M**	2.15	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	1	1	**4**
Mantsonyane Ha Mafa	Mafeteng	**M**	1.03	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**4**
Manyareleng	Butha-Buthe	**M**	11.22	3	0	0	1	1	0	0	0	0	**4**	0	0	0	0	**2**	0	0	1	1	**4**
Maoela-oela	Quthing	**M**	2.60	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**4**	0	0	1	1	**4**
Maokeng	Qacha's Nek	**M**	0.04	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	**1**	0	0	1	1	**4**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Mapakising	Mokhotlong	**M**	1.96	1	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**0**	0	0	0	0	**1**
Mapeleng	Mohale's Hoek	**M**	2.36	1	0	0	1	1	0	0	0	0	**7**	0	0	0	0	**1**	0	0	1	1	**1**
Mapeleng	Mokhotlong	**M**	22.91	7	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**4**
Maphalleng	Thaba-Tseka	**M**	16.33	5	0	0	0	0	0	0	0	0	**5**	0	0	0	0	**8**	0	0	1	1	**4**
Mapheaneng	Thaba-Tseka	**M**	4.16	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**7**	0	0	0	0	**3**
Maphenpheng	Thaba-Tseka	**M**	16.37	5	0	0	1	1	0	0	1	1	**7**	0	0	0	0	**2**	0	0	0	0	**1**
Maphotong	Mohale's Hoek	**M**	1.01	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**5**	0	0	0	0	**1**
Maphutsaneng	Mohale's Hoek	**M**	8.22	3	1	1	6	6	0	0	0	0	**10**	0	0	0	0	**1**	0	0	0	0	**1**
Maphutseng	Leribe	**M**	0.97	1	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**1**
Maphutseng	Mohale's Hoek	**M**	1.43	1	0	0	0	0	0	0	1	1	**1**	0	0	0	0	**5**	0	0	0	0	**2**
Mapolaneng	Mafeteng	**M**	0.03	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	**2**	0	0	0	0	**1**
Mapotu	Thaba-Tseka	**M**	5.45	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**0**	0	0	0	0	**3**
Maputsoe	Thaba-Tseka	**M**	4.45	2	0	0	1	1	0	0	0	0	**3**	0	0	1	1	**3**	0	0	0	0	**0**
Maqethong	Mafeteng	**M**	1.49	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**2**
Maqhatseng	Mohale's Hoek	**S**	0.09	0	0	0	1	1	0	0	1	1	**3**	0	0	1	1	**2**	0	0	0	0	**2**
Maqoala	Quthing	**M**	3.10	1	0	0	1	1	0	0	1	1	**3**	0	0	1	1	**2**	0	0	0	0	**1**
Maqoathing	Mohale's Hoek	**M**	2.90	1	0	0	3	3	0	0	0	0	**4**	0	0	0	0	**1**	0	0	0	0	**1**
Maqoathong	Quthing	**M**	6.59	2	0	0	1	1	0	0	0	0	**3**	0	0	1	1	**2**	0	0	0	0	**1**
Maqokho	Berea	**M**	0.74	1	0	0	0	0	0	0	0	0	**1**	0	0	3	3	**7**	0	0	0	0	**1**
Marabeng	Mafeteng	**M**	4.89	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**3**	0	0	0	0	**1**
Marabeng	Mohale's Hoek	**M**	0.14	1	0	0	0	0	0	0	0	0	**1**	0	0	3	3	**10**	0	0	0	0	**2**
Marakong	Mafeteng	**M**	4.69	2	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**3**
Marakong	Butha-Buthe	**M**	2.12	1	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**3**	0	0	0	0	**8**
Maralleng	Mohale's Hoek	**M**	8.70	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**2**	0	0	0	0	**1**
Maratlaheng	Thaba-Tseka	**M**	9.76	3	0	0	1	1	0	0	1	1	**5**	0	0	0	0	**1**	0	0	0	0	**3**
Maromeng	Thaba-Tseka	**M**	18.47	5	0	0	0	0	0	0	0	0	**5**	0	0	0	0	**4**	0	0	0	0	**3**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Marontoaneng	Mokhotlong	**M**	1.80	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Masakoane Ha Maama	Mohale's Hoek	**S**	1.54	1	0	0	0	0	0	0	2	2	**4**	0	0	0	0	**5**	0	0	0	0	**1**
Masakoaneng	Leribe	**M**	5.43	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**2**
Masaleng	Mokhotlong	**M**	12.58	4	0	0	0	0	0	0	0	0	**4**	1	2	0	0	**4**	0	0	0	0	**1**
Masaleng	Berea	**M**	2.18	1	0	0	1	1	0	0	0	0	**4**	0	0	0	0	**4**	0	0	0	0	**2**
Masaleng	Mokhotlong	**M**	11.67	4	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**3**
Masaleng	Maseru	**M**	0.94	1	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**3**
Masaleng	Mokhotlong	**M**	2.91	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	1	1	**3**
Masaleng Ha Taniele	Mafeteng	**S**	0.61	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**1**	0	0	0	0	**1**
Masalla	Mafeteng	**M**	3.28	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**3**
'Masemouse	Butha-Buthe	**M**	0.32	1	0	0	0	0	0	0	0	0	**1**	0	0	2	2	**4**	0	0	0	0	**5**
Maserung	Thaba-Tseka	**M**	10.26	3	0	0	0	0	0	0	0	0	**3**	0	0	2	2	**3**	0	0	0	0	**1**
Maseteleng	Leribe	**M**	0.90	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**3**
Mashai	Maseru	**M**	0.61	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Masianokeng	Mohale's Hoek	**M**	1.65	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**2**
Masianokeng	Mokhotlong	**M**	9.16	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**3**
Masoareng	Berea	**M**	4.46	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**2**
Masoefeng	Thaba-Tseka	**M**	13.45	4	1	1	2	2	0	0	1	1	**8**	0	0	0	0	**3**	0	0	0	0	**2**
Masoeling	Qacha's Nek	**M**	4.10	2	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**2**	0	0	0	0	**1**
Masokoaneng	Mohale's Hoek	**M**	0.13	1	0	0	0	0	0	0	0	0	**1**	1	2	2	2	**13**	0	0	0	0	**1**
Masucaneng	Leribe	**M**	0.45	1	0	0	0	0	0	0	0	0	**1**	0	0	2	2	**6**	0	0	0	0	**1**
Mataoeng	Mokhotlong	**M**	14.55	4	0	0	1	1	0	0	1	1	**6**	0	0	2	2	**5**	0	0	0	0	**1**
Mate Ha Selebalo	Thaba-Tseka	**M**	3.57	1	0	0	0	0	0	0	0	0	**1**	0	0	2	2	**4**	0	0	0	0	**4**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Mateanong	Maseru	**M**	9.40	3	0	0	0	0	0	0	0	0	**3**	0	0	2	2	**6**	0	0	0	0	**3**
Matebeleng	Mohale's Hoek	**M**	9.56	3	0	0	1	1	0	0	1	1	**5**	0	0	2	2	**3**	0	0	0	0	**1**
Matebeleng	Mohale's Hoek	**M**	8.88	3	0	0	0	0	0	0	0	0	**1**	0	0	2	2	**4**	0	0	0	0	**1**
Matebeleng	Mokhotlong	**M**	1.51	1	0	0	0	0	0	0	0	0	**1**	0	0	2	2	**5**	0	0	1	1	**2**
Matebeleng	Butha-Buthe	**M**	4.21	2	0	0	0	0	0	0	0	0	**2**	0	0	2	2	**5**	0	0	0	0	**2**
Matebeleng	Qacha's Nek	**M**	4.24	2	0	0	0	0	0	0	0	0	**2**	0	0	2	2	**5**	0	0	0	0	**3**
Matebeleng	Quthing	**M**	0.51	1	0	0	0	0	0	0	0	0	**3**	0	0	2	2	**5**	0	0	0	0	**4**
Mathaleng	Qacha's Nek	**S**	0.69	1	0	0	1	1	0	0	1	1	**4**	0	0	2	2	**12**	0	0	0	0	**4**
Mathole	Mokhotlong	**M**	21.16	6	0	0	1	1	0	0	0	0	**7**	0	0	2	2	**4**	0	0	0	0	**1**
Matholeng	Quthing	**M**	8.27	3	0	0	1	1	0	0	0	0	**4**	0	0	0	0	**1**	0	0	0	0	**1**
Mathuaneng	Leribe	**M**	0.09	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0	**2**
Matlali	Mokhotlong	**M**	14.96	4	0	0	1	1	0	0	0	0	**5**	0	0	0	0	**0**	0	0	0	0	**2**
Matlameng	Mafeteng	**M**	4.63	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**0**	0	0	0	0	**2**
Matlaong	Mohale's Hoek	**M**	2.15	1	0	0	1	1	0	0	0	0	**2**	0	0	2	2	**8**	0	0	0	0	**2**
Matlapaneng	Berea	**M**	3.82	2	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**3**	0	0	0	0	**1**
Matlapaneng	Qacha's Nek	**M**	4.57	2	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**3**	0	0	0	0	**3**
Matlapeng	Maseru	**M**	9.25	3	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**3**
Matlapeng	Thaba-Tseka	**M**	1.85	1	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**4**	0	0	0	0	**3**
Matlapeng Ha Thibatsane	Mafeteng	**M**	5.14	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**3**	0	0	0	0	**1**
Matlatseng	Thaba-Tseka	**M**	4.77	2	0	0	0	0	0	0	0	0	**2**	0	0	2	2	**4**	0	0	0	0	**1**
Matlatseng	Mohale's Hoek	**M**	14.47	4	0	0	0	0	0	0	1	1	**5**	0	0	2	2	**5**	0	0	0	0	**2**
Matomaneng	Thaba-Tseka	**M**	21.97	6	0	0	0	0	0	0	0	0	**6**	0	0	0	0	**3**	0	0	1	1	**4**
Matsabeng	Mokhotlong	**M**	18.93	6	2	2	3	3	0	0	0	0	**11**	0	0	1	1	**6**	0	0	0	0	**8**
Matsaile	Quthing	**M**	0.31	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**8**	0	0	0	0	**3**
Matsatsaneng	Qacha's Nek	**M**	22.57	7	0	0	0	0	0	0	0	0	**7**	0	0	0	0	**9**	0	0	0	0	**2**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Matsatseng	Quthing	**M**	2.48	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**1**
Matsikhoaneng	Thaba-Tseka	**M**	12.90	4	0	0	0	0	0	0	0	0	**4**	0	0	0	0	**7**	0	0	0	0	**2**
Matsiring	Mokhotlong	**M**	0.34	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**2**
Matsoapong	Thaba-Tseka	**M**	6.69	2	0	0	0	0	0	0	0	0	**6**	0	0	0	0	**1**	0	0	0	0	**1**
Matsoapong	Thaba-Tseka	**M**	15.77	5	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**4**	0	0	0	0	**2**
Matsoeteng	Mokhotlong	**M**	3.09	1	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**2**	0	0	0	0	**3**
Matsoetsoe	Thaba-Tseka	**M**	18.63	5	0	0	0	0	0	0	0	0	**5**	0	0	0	0	**5**	0	0	0	0	**2**
Matsoiring	Mafeteng	**M**	2.02	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**0**
Matsolong	Mafeteng	**M**	1.58	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**5**	0	0	0	0	**2**
Matsooeng	Maseru	**M**	0.12	1	0	0	1	1	0	0	0	0	**2**	0	0	2	2	**6**	0	0	0	0	**1**
Matsoseng	Maseru	**M**	1.54	1	0	0	0	0	0	0	0	0	**1**	0	0	2	2	**6**	0	0	0	0	**1**
Matukeng	Butha-Buthe	**M**	0.14	1	0	0	0	0	0	0	0	0	**1**	0	0	2	2	**4**	0	0	0	0	**1**
Mauteng	Mohale's Hoek	**M**	3.01	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Mechachaneng	Mohale's Hoek	**M**	2.47	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**3**
Meeling	Maseru	**M**	1.64	1	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**1**	0	0	1	1	**4**
Mekaling Ha Nkhemeleng	Thaba-Tseka	**M**	15.75	5	1	1	1	1	0	0	1	1	**8**	0	0	0	0	**1**	0	0	0	0	**2**
Mekateng	Thaba-Tseka	**M**	4.87	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**0**
Meriting	Thaba-Tseka	**M**	7.94	3	1	1	1	1	0	0	0	0	**5**	0	0	0	0	**9**	0	0	0	0	**2**
Mespeng Ha Pheto	Mafeteng	**M**	1.26	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**7**
Methalaneng Ha Mahapela	Maseru	**M**	4.79	2	0	0	0	0	0	0	1	1	**3**	0	0	1	1	**5**	0	0	0	0	**1**
Methinyeng	Quthing	**M**	1.27	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**1**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Metlaeeng	Butha-Buthe	**M**	1.23	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**3**
Metsi-Masooana	Thaba-Tseka	**M**	5.25	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**3**
Moaloseng	Maseru	**M**	1.36	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**4**
Moeaneng	Mokhotlong	**M**	0.78	1	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**1**
Moeaneng	Mafeteng	**M**	2.97	1	0	0	1	1	0	0	1	1	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Moeaneng	Mafeteng	**M**	0.43	1	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**2**
Moeaneng	Maseru	**M**	4.06	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**4**	0	0	1	1	**3**
Moeaneng	Mokhotlong	**S**	0.80	1	0	0	1	1	0	0	1	1	**4**	0	0	2	2	**5**	0	0	0	0	**3**
Moeling	Mokhotlong	**M**	0.55	1	0	0	0	0	0	0	0	0	**1**	0	0	2	2	**2**	0	0	0	0	**1**
Moeling	Mohale's Hoek	**M**	1.35	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**7**	0	0	0	0	**1**
Mofolaneng	Quthing	**M**	2.38	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**3**
Mohalinyane	Maseru	**M**	3.17	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**2**
Mohlakaneng	Thaba-Tseka	**M**	1.89	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Mohlaka-oa-tuka	Mafeteng	**M**	8.23	3	0	0	1	1	0	0	1	1	**5**	0	0	0	0	**1**	0	0	0	0	**1**
Mohlakeng	Thaba-Tseka	**M**	8.66	3	0	0	0	0	0	0	1	1	**4**	0	0	0	0	**1**	0	0	0	0	**1**
Mohlanapeng	Mokhotlong	**M**	1.28	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Mohlanapeng	Thaba-Tseka	**M**	0.54	1	0	0	1	1	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Mohlanapeng	Qacha's Nek	**M**	19.71	6	0	0	1	1	0	0	1	1	**2**	0	0	0	0	**3**	0	0	0	0	**1**
Mohlanapeng	Maseru	**M**	0.19	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**15**	0	0	0	0	**1**
Mohlanapeng	Butha-Buthe	**M**	3.44	1	0	0	0	0	0	0	0	0	**8**	0	0	1	1	**2**	0	0	0	0	**7**
Mohokare Ha Setho	Leribe	**M**	0.08	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	**2**	0	0	0	0	**6**
Moholeng	Quthing	**M**	0.14	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	1	1	**5**
Mohope	Quthing	**M**	1.15	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**0**	0	0	1	1	**2**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Mokananhelong	Maseru	**M**	1.28	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Mokekeng	Mohale's Hoek	**M**	7.88	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**3**
Mokema	Thaba-Tseka	**M**	0.19	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**2**
Mokhalimesto Ha Phafoli	Mohale's Hoek	**M**	2.60	1	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**3**	0	0	0	0	**2**
Mokhangoaneno	Maseru	**M**	1.01	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**7**
Mokhele Ha Tloko	Qacha's Nek	**M**	7.61	3	0	0	0	0	0	0	1	1	**4**	0	0	1	1	**2**	0	0	0	0	**1**
Mokhokhong	Leribe	**M**	1.54	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**2**
Mokholoke Ha Sepechele	Berea	**M**	6.50	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**3**	0	0	1	1	**4**
Mokoailong	Mohale's Hoek	**M**	11.08	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**2**	0	0	0	0	**1**
Mokomahatsi	Butha-Buthe	**M**	0.42	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**1**
Mokopung Ha Nkau	Maseru	**M**	7.88	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**4**	0	0	1	1	**3**
Mokotjela	Thaba-Tseka	**M**	2.77	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	0	0	**2**
Mokotleng	Maseru	**M**	11.84	4	0	0	0	0	0	0	0	0	**6**	0	0	0	0	**1**	0	0	0	0	**1**
Mokotleng	Mokhotlong	**M**	4.28	2	0	0	3	3	0	0	1	1	**4**	0	0	0	0	**3**	0	0	0	0	**3**
Molikaliko	Mafeteng	**M**	0.29	1	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**3**	0	0	0	0	**1**
Molikaliko	Mokhotlong	**M**	6.79	2	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	0	0	**1**
Molomo's Hoek	Thaba-Tseka	**M**	10.22	3	0	0	0	0	0	0	1	1	**4**	0	0	1	1	**3**	0	0	0	0	**2**
Mongobong	Mohale's Hoek	**M**	7.76	3	0	0	1	1	0	0	3	3	**7**	0	0	1	1	**3**	0	0	0	0	**2**
Mononong	Mokhotlong	**M**	2.92	1	0	0	1	1	0	0	1	1	**3**	0	0	1	1	**4**	0	0	0	0	**1**

Village Name	**District**	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Monyameng	Qacha's Nek	**M**	3.08	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**5**	0	0	0	0	**3**
Moqane	Mohale's Hoek	**M**	2.62	1	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**1**	0	0	0	0	**3**
Moqoqeleng	Butha-Buthe	**M**	2.03	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**5**
Moreneng Ha Goliathe	Mohale's Hoek	**M**	6.40	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	1	1	**4**
Morifi	Mohale's Hoek	**M**	4.46	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**2**
Morifi Ha Rakoloi	Mokhotlong	**M**	5.16	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**4**	0	0	0	0	**1**
Morobong	Mohale's Hoek	**M**	12.61	4	0	0	0	0	0	0	1	1	**5**	0	0	1	1	**6**	0	0	0	0	**1**
Morojeleng	Mafeteng	**S**	0.30	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**2**	0	0	0	0	**1**
Moru-Motso	Qacha's Nek	**M**	3.88	2	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**5**	0	0	0	0	**1**
Morunyaneng	Quthing	**M**	1.91	1	0	0	1	1	0	0	1	1	**3**	0	0	1	1	**3**	0	0	0	0	**3**
Mosafeleng	Qacha's Nek	**M**	21.24	6	0	0	0	0	0	0	0	0	**4**	0	0	1	1	**3**	0	0	0	0	**2**
Mosafeleng	Qacha's Nek	**M**	4.10	2	0	0	1	1	0	0	1	1	**6**	0	0	1	1	**5**	0	0	0	0	**4**
Mosamaqa	Thaba-Tseka	**M**	5.50	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**6**	0	0	0	0	**3**
Mosaqane Ha Thaha	Thaba-Tseka	**M**	17.11	5	0	0	0	0	0	0	1	1	**6**	1	2	1	1	**5**	0	0	0	0	**1**
Moseaneng	Qacha's Nek	**M**	13.33	4	0	0	0	0	0	0	0	0	**4**	0	0	1	1	**3**	0	0	0	0	**1**
Mosehle Ha Jacob	Mokhotlong	**M**	8.46	3	0	0	0	0	0	0	1	1	**4**	0	0	1	1	**6**	0	0	0	0	**1**
Mosenekeng	Mokhotlong	**M**	5.47	2	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**5**	0	0	0	0	**2**
Moshemong	Maseru	**S**	0.04	0	0	0	1	1	0	0	1	1	**3**	0	0	1	1	**4**	0	0	0	0	**1**
Mosiuoa	Maseru	**M**	11.87	4	0	0	1	1	0	0	1	1	**6**	1	2	1	1	**5**	0	0	0	0	**1**
Moste-Mocha	Mohale's Hoek	**M**	1.18	1	0	0	0	0	0	0	0	0	**3**	1	2	1	1	**3**	0	0	0	0	**1**
Moste-Mocha	Butha-Buthe	**M**	0.52	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**10**	0	0	0	0	**1**
Moste-Mocha	Maseru	**M**	3.82	2	0	0	1	1	0	0	0	0	**1**	0	0	1	1	**8**	0	0	0	0	**3**

Village Name	**District**	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Mothetsa	Quthing	**M**	0.09	0	0	0	0	0	0	0	0	0	**0**	0	0	1	1	**3**	0	0	0	0	**1**
Motlaputseng	Quthing	**M**	6.06	2	0	0	0	0	0	0	1	1	**3**	0	0	8	8	**11**	0	0	0	0	**1**
Motse Mocha	Mokhotlong	**M**	13.42	4	0	0	1	1	0	0	0	0	**5**	0	0	8	8	**9**	0	0	0	0	**1**
Motsekuoa Ha Selebalo	Mokhotlong	**M**	5.57	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**3**	0	0	0	0	**1**
Motsitseng	Mohale's Hoek	**M**	5.17	2	0	0	0	0	0	0	1	1	**3**	0	0	1	1	**6**	0	0	0	0	**1**
Motsitseng Ha Matlere	Leribe	**M**	3.70	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	0	0	**0**
Motsoanakaba	Leribe	**M**	0.07	0	0	0	0	0	0	0	0	0	**0**	0	0	1	1	**3**	0	0	0	0	**2**
Motsoene	Mohale's Hoek	**M**	0.88	1	0	0	1	1	0	0	0	0	**2**	0	0	1	1	**2**	0	0	1	1	**3**
Mpharane	Quthing	**S**	0.30	1	0	0	0	0	0	0	1	1	**4**	1	2	1	1	**2**	0	0	0	0	**1**
Mpharane	Mohale's Hoek	**M**	5.03	2	0	0	1	1	0	0	1	1	**5**	0	0	1	1	**4**	0	0	0	0	**1**
Mpharane	Qacha's Nek	**M**	0.15	1	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**5**	0	0	0	0	**1**
Mpharane	Leribe	**M**	4.20	2	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	0	0	**3**
Mpharane	Quthing	**M**	13.27	4	0	0	0	0	0	0	1	1	**3**	0	0	2	2	**6**	0	0	0	0	**4**
Mphoche	Mohale's Hoek	**M**	15.42	5	0	0	0	0	0	0	0	0	**5**	0	0	1	1	**3**	0	0	0	0	**1**
Mphojoa	Mokhotlong	**M**	13.55	4	0	0	0	0	0	0	0	0	**4**	0	0	0	0	**4**	0	0	1	1	**3**
Mphoko	Leribe	**M**	0.28	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**5**	0	0	0	0	**2**
Mphokojoane	Leribe	**M**	0.25	1	0	0	0	0	0	0	0	0	**1**	0	0	3	3	**10**	0	0	0	0	**1**
Mphorosane	Berea	**M**	4.67	2	0	0	0	0	0	0	0	0	**2**	0	0	2	2	**5**	0	0	0	0	**1**
Mphosong Ha Tefo	Mohale's Hoek	**M**	4.84	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**1**
Mphunyetsane	Butha-Buthe	**M**	1.00	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	1	1	**3**
Mphuthela	Leribe	**M**	3.10	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**1**
Muela	Mohale's Hoek	**M**	3.01	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**1**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Muela Ha Taemane	Quthing	**M**	0.96	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Nama-u-lule	Maseru	**M**	5.88	2	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**2**	0	0	0	0	**1**
Ndungwana	Maseru	**S**	0.45	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**2**	0	0	0	0	**5**
Ngope-Khubelu Ha Makhube	Quthing	**M**	8.37	3	0	0	1	1	0	0	0	0	**4**	0	0	0	0	**2**	0	0	0	0	**5**
Ngope-Tsoeu Ha Ngaka	Mafeteng	**M**	3.92	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**3**	0	0	0	0	**1**
Nice Field	Quthing	**M**	1.22	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**3**	0	0	0	0	**6**
Nkete	Maseru	**S**	0.37	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**2**	0	0	0	0	**2**
Nking Ha Lesaoana	Qacha's Nek	**M**	21.57	6	0	0	0	0	0	0	0	0	**6**	0	0	1	1	**4**	0	0	0	0	**1**
Nkoeng	Mokhotlong	**M**	25.36	7	0	0	1	1	0	0	1	1	**1**	0	0	0	0	**7**	0	0	0	0	**1**
Nkoeng	Quthing	**M**	1.22	1	0	0	0	0	0	0	0	0	**9**	0	0	0	0	**3**	0	0	0	0	**2**
Nkokamele	Thaba-Tseka	**M**	7.54	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**9**	0	0	0	0	**1**
Nkomandeni	Berea	**M**	3.73	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Noha-lia-loana	Mokhotlong	**M**	2.05	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**3**
Nokong	Thaba-Tseka	**M**	8.73	3	0	0	0	0	0	0	1	1	**4**	0	0	0	0	**1**	0	0	0	0	**1**
Nqobelle	Maseru	**M**	1.36	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	1	1	**4**
Nqoellane	Berea	**M**	3.78	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**3**	0	0	0	0	**1**
Ntlo-Kholo	Mokhotlong	**M**	11.58	4	0	0	0	0	0	0	0	0	**4**	0	0	0	0	**3**	0	0	0	0	**7**
Ntsirele	Maseru	**S**	0.33	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**2**	0	0	0	0	**2**
Ntsoanatsatsi	Leribe	**M**	0.81	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	0	0	**7**
Nyakosoba	Quthing	**M**	0.69	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**2**
Orlando	Mokhotlong	**M**	9.18	3	2	2	3	3	0	0	0	0	**8**	0	0	0	0	**2**	0	0	0	0	**1**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Paballong	Thaba-Tseka	**M**	1.79	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**2**
Pae-la-Itlhatsoa	Mokhotlong	**M**	11.80	4	0	0	1	1	0	0	1	1	**6**	0	0	2	2	**8**	0	0	1	1	**3**
Parafine Ha Long	Thaba-Tseka	**M**	19.19	6	0	0	1	1	0	0	0	0	**7**	0	0	0	0	**1**	1	2	2	2	**6**
Patiseng	Thaba-Tseka	**M**	2.01	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**5**	0	0	0	0	**1**
Patiseng Ha Sefaha	Butha-Buthe	**M**	17.34	5	0	0	1	1	0	0	0	0	**6**	0	0	0	0	**7**	0	0	1	1	**3**
Patsing	Maseru	**M**	2.09	1	0	0	1	1	0	0	0	0	**2**	0	0	1	1	**3**	0	0	0	0	**3**
Patuoe	Qacha's Nek	**M**	2.59	1	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**7**	0	0	0	0	**3**
Pentseng	Thaba-Tseka	**M**	2.32	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	1	1	**4**
Pepeneneng	Mokhotlong	**M**	10.78	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**1**
Phaatjana	Quthing	**M**	0.99	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	1	1	**3**
Phahameng	Thaba-Tseka	**M**	9.65	3	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Phahameng	Mokhotlong	**M**	1.92	1	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**5**	0	0	0	0	**4**
Pharahlahle Ha Bera	Mohale's Hoek	**M**	1.21	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	1	1	**5**
Phatlalla	Qacha's Nek	**M**	0.15	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**5**
Phatlalla	Butha-Buthe	**M**	0.15	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	1	1	**5**
Pheellong Ha Mpiti	Maseru	**S**	0.46	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**1**	0	0	0	0	**0**
Phelantaba	Mohale's Hoek	**M**	4.00	2	0	0	1	1	0	0	2	2	**5**	0	0	0	0	**1**	0	0	1	1	**6**
Pheuoeng	Mafeteng	**M**	7.36	2	0	0	1	1	0	0	3	3	**6**	0	0	0	0	**2**	0	0	0	0	**3**
Phiring	Quthing	**M**	5.56	2	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**2**	0	0	1	1	**3**
Phocha	Butha-Buthe	**M**	0.14	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	1	1	**4**
Phocha	Maseru	**M**	2.21	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**2**	0	0	1	1	**5**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Phoku	Thaba-Tseka	**M**	5.65	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**1**	0	0	1	1	**3**
Phomolo	Berea	**M**	0.04	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	**2**	0	0	1	1	**3**
Phororong	Leribe	**M**	9.60	3	0	0	0	0	0	0	1	1	**4**	0	0	0	0	**3**	0	0	1	1	**4**
Phororong Ha Molikuoa	Thaba-Tseka	**M**	17.21	5	0	0	0	0	0	0	0	0	**5**	0	0	0	0	**0**	0	0	1	1	**4**
Phukheng	Mohale's Hoek	**M**	6.26	2	0	0	0	0	0	0	1	1	**3**	0	0	2	2	**6**	0	0	1	1	**4**
Phuleng	Qacha's Nek	**M**	1.71	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**5**	0	0	1	1	**3**
Phuthing	Qacha's Nek	**M**	3.61	1	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**2**	0	0	0	0	**1**
Phuthing	Berea	**M**	3.93	2	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**3**
Phuthing Ha Lesala	Thaba-Tseka	**M**	6.80	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**1**
Pitsaneng Ha Moshati	Thaba-Tseka	**M**	6.71	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**3**	0	0	0	0	**0**
Pitseng	Leribe	**M**	6.31	2	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	1	1	**3**
Pitseng	Quthing	**M**	0.47	1	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	1	1	**4**
Pobeng Ha Ramaboella	Mohale's Hoek	**M**	9.34	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**2**	0	0	0	0	**1**
Pokane Ha Kabi	Maseru	**S**	0.89	1	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**1**	0	0	1	1	**3**
Polasi	Mohale's Hoek	**M**	0.18	1	0	0	0	0	0	0	0	0	**1**	0	0	2	2	**5**	0	0	0	0	**2**
Polateng	Maseru	**M**	5.94	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**1**	0	0	1	1	**3**
Pontseng	Quthing	**M**	3.18	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	1	1	**3**
Pontseng	Leribe	**M**	2.97	1	0	0	0	0	0	0	0	0	**8**	0	0	2	2	**1**	0	0	0	0	**4**
Pontseng	Quthing	**M**	0.32	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**5**
Pontseng	Thaba-Tseka	**M**	21.02	6	0	0	1	1	0	0	1	1	**1**	0	0	0	0	**4**	0	0	0	0	**7**
Pontseng	Leribe	**M**	0.11	1	0	0	0	0	0	0	0	0	**1**	0	0	2	2	**1**	0	0	1	1	**8**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Pontseng Ha Setontol	Mohale's Hoek	**M**	4.75	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**6**	0	0	1	1	**3**
Popopo	Mohale's Hoek	**M**	3.62	1	0	0	0	0	0	0	0	0	**1**	0	0	2	2	**4**	0	0	0	0	**1**
Qabanyane Ha Malinyane	Mohale's Hoek	**M**	9.52	3	0	0	0	0	0	0	1	1	**4**	0	0	2	2	**4**	0	0	1	1	**6**
Qalike Ha Monare	Mohale's Hoek	**M**	6.29	2	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**3**	0	0	1	1	**5**
Qaphane	Qacha's Nek	**M**	18.74	5	0	0	0	0	0	0	0	0	**5**	0	0	0	0	**3**	0	0	1	1	**4**
Qaqatu Ha Moroko	Mohale's Hoek	**M**	7.82	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**2**	0	0	0	0	**4**
Qenehelong	Qacha's Nek	**M**	15.46	5	0	0	0	0	0	0	1	1	**6**	0	0	1	1	**8**	0	0	0	0	**4**
Qhoasing Ha Kori	Butha-Buthe	**M**	0.77	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	1	1	**4**
Qhobosheaneng	Leribe	**M**	2.46	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**5**	0	0	0	0	**1**
Qholaqhoe	Maseru	**M**	0.84	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	1	1	**5**
Qhophello	Maseru	**M**	3.02	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**2**	0	0	1	1	**3**
Qiloane Ha Khoabane	Thaba-Tseka	**M**	1.18	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**1**	0	0	1	1	**4**
Qiloane Ha Phafoli	Mokhotlong	**M**	13.45	4	0	0	1	1	0	0	0	0	**5**	0	0	0	0	**1**	0	0	1	1	**4**
Qobacha	Mohale's Hoek	**M**	10.43	3	0	0	0	0	0	0	1	1	**4**	0	0	0	0	**1**	0	0	0	0	**3**
Qobellong	Mohale's Hoek	**M**	13.25	4	0	0	0	0	0	0	1	1	**5**	0	0	0	0	**5**	0	0	0	0	**1**
Qobong Ha Sebili	Berea	**M**	2.90	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**2**

Village Name	**District**	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Qobong Ha Tsiu	Mohale's Hoek	**M**	1.10	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**5**	0	0	0	0	**2**
Qopo	Mohale's Hoek	**M**	0.77	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**3**
Qoqolosing Ha Tsebe	Leribe	**M**	0.19	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	1	1	**5**
Qotiane Ha Mopeli	Mokhotlong	**M**	12.27	4	0	0	1	1	0	0	0	0	**5**	0	0	0	0	**1**	0	0	0	0	**5**
Rampai's	Mafeteng	**M**	4.69	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**3**	0	0	1	1	**5**
Rapeising	Maseru	**M**	2.58	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**4**	0	0	0	0	**6**
Reisi	Quthing	**M**	4.65	2	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**2**	0	0	0	0	**3**
Ribaneng	Qacha's Nek	**M**	17.94	5	0	0	1	1	0	0	0	0	**6**	0	0	0	0	**1**	0	0	0	0	**1**
Rothe	Butha-Buthe	**M**	0.32	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	1	1	**7**
Rothifa	Mokhotlong	**M**	0.17	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**5**	0	0	1	1	**4**
Sabaila	Mohale's Hoek	**M**	2.82	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**1**	0	0	1	1	**4**
Saiangj	Mohale's Hoek	**M**	2.86	1	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**2**	0	0	0	0	**3**
Sakhele Ha Lekhutla	Quthing	**M**	0.60	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**3**
Salang	Mohale's Hoek	**M**	0.69	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**4**
Sdakeni	Thaba-Tseka	**M**	3.07	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**2**
Seaka	Mohale's Hoek	**M**	8.99	3	0	0	0	0	0	0	1	1	**4**	0	0	0	0	**2**	0	0	1	1	**4**
Sealemetse	Leribe	**M**	2.79	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**8**
Sealuma	Berea	**M**	1.38	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	0	0	**1**
Sebalabala	Mohale's Hoek	**M**	7.20	2	0	0	0	0	0	0	0	0	**2**	0	0	4	4	**6**	0	0	1	1	**5**
Sebala-bala	Butha-Buthe	**M**	2.67	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	0	0	**4**
Sebaretlane Ha Malatsi	Mokhotlong	**M**	0.83	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Sebataolong	Mohale's Hoek	**M**	1.21	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**2**	0	0	0	0	**1**
Sebera	Mohale's Hoek	**M**	4.77	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	1	1	**3**
Sebetlaneng	Berea	**M**	3.19	1	0	0	1	1	0	0	1	1	**3**	0	0	1	1	**2**	0	0	1	1	**3**
Sefateng	Mokhotlong	**M**	8.99	3	0	0	0	0	0	0	1	1	**6**	0	0	0	0	**3**	0	0	1	1	**3**
Sefateng	Thaba-Tseka	**M**	6.45	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	1	1	**4**
Sefateng	Mohale's Hoek	**M**	17.09	5	0	0	0	0	0	0	1	1	**4**	0	0	0	0	**3**	0	0	0	0	**7**
Sehaula	Mokhotlong	**M**	0.41	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	0	0	**1**
Sehaula	Quthing	**M**	2.99	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**6**	0	0	1	1	**3**
Sehlabeng	Quthing	**M**	0.29	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**1**	0	0	1	1	**3**
Sehlabeng	Mohale's Hoek	**M**	4.03	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**4**
Sehutloaneng	Mafeteng	**M**	4.62	2	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**1**	0	0	0	0	**4**
Sekameng	Mafeteng	**M**	0.92	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**4**
Sekameng	Qacha's Nek	**M**	2.22	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**2**	0	0	0	0	**6**
Sekantsing	Quthing	**M**	1.38	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**1**	0	0	1	1	**5**
Sekhalabateng	Quthing	**M**	13.67	4	0	0	0	0	0	0	1	1	**5**	0	0	1	1	**3**	0	0	0	0	**1**
Sekhaola	Mohale's Hoek	**M**	4.20	2	0	0	0	0	0	0	0	0	**2**	0	0	6	6	**9**	0	0	1	1	**4**
Sekhutlong	Quthing	**M**	13.96	4	0	0	0	0	0	0	2	2	**4**	0	0	1	1	**5**	0	0	1	1	**1**
Sekhutlong	Mokhotlong	**M**	5.29	2	0	0	0	0	0	0	1	1	**1**	0	0	1	1	**4**	0	0	1	1	**2**
Sekhutlong	Mohale's Hoek	**S**	0.72	1	0	0	1	1	0	0	1	1	**2**	0	0	1	1	**2**	0	0	0	0	**4**
Sekhutlong	Mohale's Hoek	**M**	1.34	1	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**3**	0	0	0	0	**4**
Sekhutlong	Mafeteng	**M**	0.46	1	0	0	0	0	0	0	0	0	**6**	0	0	1	1	**6**	0	0	0	0	**6**
Sekhutlong Ha Koko	Mohale's Hoek	**M**	14.31	4	0	0	0	0	0	0	1	1	**5**	0	0	0	0	**2**	0	0	0	0	**6**
Sekiring	Leribe	**M**	2.85	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	0	0	**1**
Sekitsing	Thaba-Tseka	**M**	0.20	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	1	1	**4**
Sekoaing	Mokhotlong	**M**	6.44	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**2**	0	0	0	0	**2**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Sekofing	Mokhotlong	**M**	12.84	4	0	0	0	0	0	0	1	1	**5**	0	0	2	2	**4**	0	0	0	0	**0**
Sekoka	Qacha's Nek	**S**	0.42	1	0	0	1	1	0	0	1	1	**4**	0	0	2	2	**4**	0	0	1	1	**6**
Sekokoaneng	Quthing	**M**	1.85	1	0	0	0	0	0	0	1	1	**1**	1	2	2	2	**4**	0	0	1	1	**1**
Sekokoaneng	Mokhotlong	**M**	2.35	1	0	0	0	0	0	0	0	0	**1**	0	0	2	2	**6**	0	0	0	0	**1**
Sekokoaneng	Berea	**M**	0.49	1	0	0	0	0	0	0	0	0	**2**	0	0	2	2	**8**	0	0	0	0	**3**
Sekokong	Quthing	**M**	20.58	6	0	0	1	1	0	0	0	0	**4**	0	0	2	2	**1**	0	0	1	1	**5**
Sekokong	Qacha's Nek	**M**	10.66	3	0	0	0	0	0	0	1	1	**7**	0	0	0	0	**3**	0	0	0	0	**6**
Sekolong Ha Sekonyela	Thaba-Tseka	**M**	6.96	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**6**	0	0	1	1	**5**
Sekoti	Maseru	**M**	0.08	0	0	0	1	1	0	0	0	0	**1**	0	0	2	2	**5**	0	0	0	0	**1**
Sekoting	Mohale's Hoek	**M**	4.77	2	0	0	0	0	0	0	0	0	**2**	0	0	2	2	**4**	0	0	1	1	**3**
Semonkoaneng	Leribe	**M**	5.98	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**0**	0	0	1	1	**3**
Senqu Ha Pata	Berea	**M**	1.17	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**1**
Senyenyane	Thaba-Tseka	**S**	0.93	1	0	0	0	0	0	0	1	1	**3**	0	0	2	2	**4**	0	0	1	1	**5**
Senyotong	Thaba-Tseka	**M**	9.40	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**1**	0	0	1	1	**4**
Sephareng	Butha-Buthe	**M**	1.07	1	0	0	0	0	0	0	0	0	**1**	1	2	0	0	**3**	0	0	0	0	**7**
Sephokong	Mohale's Hoek	**M**	3.67	1	0	0	0	0	0	0	1	1	**2**	0	0	2	2	**5**	0	0	0	0	**1**
Seqhobong	Mohale's Hoek	**M**	1.45	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**1**	0	0	1	1	**3**
Seroto Ha Ramosothoana	Thaba-Tseka	**M**	13.22	4	0	0	0	0	0	0	0	0	**4**	0	0	2	2	**3**	0	0	0	0	**7**
Seshaing	Mohale's Hoek	**M**	5.25	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**2**	0	0	1	1	**4**
Setanteng	Qacha's Nek	**M**	1.58	1	0	0	0	0	0	0	1	1	**2**	0	0	2	2	**6**	0	0	0	0	**0**
Sethaleng		**M**	0.36	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	1	1	**4**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Sethebeng	Maseru	**S**	0.37	1	0	0	1	1	0	0	1	1	**4**	0	0	2	2	**5**	0	0	1	1	**3**
Sethepung	Butha-Buthe	**M**	0.10	0	0	0	0	0	0	0	0	0	**0**	0	0	4	4	**6**	0	0	0	0	**1**
Setibing	Maseru	**S**	0.97	1	0	0	2	2	0	0	1	1	**5**	0	0	2	2	**4**	0	0	1	1	**4**
Setlakalleng	Thaba-Tseka	**M**	10.58	3	0	0	0	0	0	0	1	1	**4**	0	0	2	2	**3**	0	0	1	1	**2**
Setleketseng	Butha-Buthe	**M**	13.18	4	4	4	3	3	0	0	1	1	**12**	0	0	2	2	**4**	0	0	1	1	**4**
Setoetoe	Qacha's Nek	**S**	0.63	1	0	0	1	1	0	0	1	1	**4**	0	0	2	2	**5**	0	0	0	0	**1**
Setonong	Mohale's Hoek	**S**	0.28	1	0	0	0	0	0	0	1	1	**3**	0	0	1	1	**12**	0	0	1	1	**5**
Shakhane	Butha-Buthe	**M**	0.62	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**0**	0	0	0	0	**2**
Shalane	Quthing	**M**	5.20	2	0	0	0	0	0	0	1	1	**3**	0	0	2	2	**4**	0	0	1	1	**4**
Sheeshe	Qacha's Nek	**S**	0.78	1	0	0	0	0	0	0	1	1	**3**	0	0	2	2	**4**	0	0	0	0	**2**
Sinxondo (Shopong)	Mohale's Hoek	**M**	0.17	1	0	0	0	0	0	0	0	0	**1**	0	0	2	2	**9**	0	0	1	1	**5**
Siqiking	Mohale's Hoek	**S**	0.26	1	0	0	0	0	0	0	1	1	**3**	0	0	0	0	**3**	0	0	0	0	**1**
Souru Ha Mosuoe	Quthing	**M**	2.28	1	0	0	0	0	0	0	1	1	**2**	0	0	0	0	**1**	0	0	1	1	**5**
Stanteng	Mafeteng	**M**	1.71	1	0	0	0	0	0	0	1	1	**2**	0	0	1	1	**3**	0	0	0	0	**5**
Sutha	Mafeteng	**M**	0.25	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**5**	0	0	1	1	**4**
Tafoleng	Quthing	**M**	1.92	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**4**
Tajane	Leribe	**M**	1.19	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**6**
Takalatsa	Butha-Buthe	**M**	0.48	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**5**
Takisa	Leribe	**M**	3.60	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**2**
Tale	Thaba-Tseka	**M**	1.82	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Tamaseka	Mokhotlong	**M**	0.69	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**3**
Taung	Thaba-Tseka	**M**	6.57	2	0	0	0	0	0	0	1	1	**0**	0	0	0	0	**2**	0	0	1	1	**3**
Taung	Quthing	**M**	1.07	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**4**
Taung	Butha-Buthe	**M**	0.05	0	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**1**	0	0	1	1	**4**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Taung		**M**	0.09	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	**1**	0	0	1	1	**5**
Taung	Mohale's Hoek	**M**	4.97	2	0	0	0	0	0	0	0	0	**2**	0	0	####	##	**0**	0	0	1	1	**6**
Tebetebe	Mokhotlong	**M**	0.61	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**0**	0	0	1	1	**4**
Tele-Tele	Mohale's Hoek	**M**	16.19	5	0	0	0	0	0	0	0	0	**5**	0	0	0	0	**0**	0	0	1	1	**3**
Telite	Mafeteng	**M**	0.93	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	1	1	**6**
Tena-Baphehi Ha Ntjabokone	Thaba-Tseka	**M**	8.92	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**4**
Tesi	Mafeteng	**M**	1.13	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**5**	0	0	1	1	**4**
Thaba	Mokhotlong	**M**	16.09	5	0	0	0	0	0	0	0	0	**5**	0	0	0	0	**1**	0	0	1	1	**4**
Thaba-Bosiu	Thaba-Tseka	**M**	6.36	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	1	1	**4**
Thaba-Bosiu	Mokhotlong	**M**	5.75	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**4**	0	0	1	1	**4**
Thaba-Chitja	Qacha's Nek	**M**	12.17	4	0	0	0	0	0	0	0	0	**4**	0	0	0	0	**5**	0	0	0	0	**1**
Thaba-Khubelu	Mokhotlong	**M**	6.61	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**1**
Thaba-Khubelu	Mokhotlong	**M**	22.08	6	2	2	3	3	0	0	1	1	**12**	0	0	0	0	**3**	0	0	0	0	**1**
Thaba-Koto Ha Ramotheba	Maseru	**M**	2.96	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	0	0	**6**
Thaba-li-Mpe	Berea	**M**	0.32	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	0	0	**4**
Thaba-Moea	Mohale's Hoek	**M**	0.61	1	0	0	0	0	0	0	0	0	**1**	1	2	0	0	**11**	0	0	0	0	**3**
Thabana-Tsobana	Maseru	**M**	0.41	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**2**	0	0	1	1	**5**
Thabana-Tsooana	Mokhotlong	**M**	4.44	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	1	1	**5**
Thabaneng	Thaba-Tseka	**M**	16.89	5	0	0	0	0	0	0	0	0	**5**	0	0	0	0	**1**	0	0	0	0	**2**
Thabang	Mokhotlong	**M**	2.37	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**4**
Thabang	Thaba-Tseka	**M**	7.41	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**4**	0	0	1	1	**4**
Thaba-Ntso	Qacha's Nek	**M**	0.37	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**6**	0	0	0	0	**1**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Thaba-Ntso	Butha-Buthe	**M**	0.96	1	0	0	2	2	0	0	0	0	**3**	0	0	0	0	**1**	0	0	1	1	**4**
Thaba-Sephara	Qacha's Nek	**M**	5.81	2	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**2**	0	0	1	1	**5**
Thaba-Tsoeu	Berea	**M**	1.76	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Thabong	Maseru	**M**	4.92	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	1	1	**4**
Thamathu	Qacha's Nek	**M**	4.65	2	0	0	0	0	0	0	1	1	**3**	1	2	0	0	**6**	0	0	0	0	**4**
Thana Ha Jane	Thaba-Tseka	**M**	12.77	4	0	0	0	0	0	0	0	0	**4**	0	0	1	1	**2**	0	0	1	1	**3**
Theetsoa Ha Mphephe	Mohale's Hoek	**S**	0.92	1	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**3**	0	0	1	1	**3**
Thena	Mohale's Hoek	**M**	6.21	2	0	0	0	0	0	0	1	1	**3**	1	2	1	1	**6**	0	0	1	1	**6**
Thepung	Qacha's Nek	**M**	4.24	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**4**	0	0	1	1	**5**
Thibella	Thaba-Tseka	**M**	1.59	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**3**
Thifa	Leribe	**M**	1.03	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**3**	0	0	0	0	**2**
Thifa Maluma	Berea	**M**	3.70	1	0	0	1	1	0	0	0	0	**2**	0	0	1	1	**11**	0	0	1	1	**3**
Tholang	Butha-Buthe	**M**	6.91	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**5**	0	0	1	1	**4**
Thopo	Butha-Buthe	**M**	18.04	5	4	4	3	3	0	0	0	0	**12**	0	0	1	1	**2**	0	0	1	1	**5**
Thota-Peli	Mokhotlong	**M**	23.46	7	0	0	1	1	0	0	0	0	**8**	0	0	6	6	**8**	0	0	1	1	**6**
Thoteng	Maseru	**M**	3.34	1	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**18**	0	0	0	0	**3**
Thoteng	Maseru	**S**	0.83	1	0	0	0	0	0	0	1	1	**1**	0	0	1	1	**3**	0	0	1	1	**4**
Thoteng Ha Khethisa	Qacha's Nek	**M**	8.88	3	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**9**	0	0	0	0	**5**
Thoteng Ha Nkhema	Maseru	**S**	0.06	0	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**2**	0	0	0	0	**3**
Thoteng-ea-Moli	Mafeteng	**M**	6.74	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**1**	0	0	0	0	**6**
Thueleng	Quthing	**M**	1.79	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**3**	0	0	1	1	**3**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Thusong		**M**	2.53	1	0	0	1	1	0	0	1	1	**3**	0	0	0	0	**0**	0	0	1	1	**3**
Tibeleng	Quthing	**M**	1.69	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	1	1	**5**
Tikeng	Quthing	**M**	8.63	3	0	0	0	0	0	0	0	0	**3**	0	0	0	0	**1**	0	0	0	0	**5**
Tikoko	Leribe	**M**	6.28	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	0	0	**3**
Tipana	Mokhotlong	**M**	18.53	5	0	0	0	0	0	0	1	1	**6**	0	0	0	0	**3**	0	0	1	1	**6**
Tiping	Mohale's Hoek	**S**	0.21	1	0	0	1	1	0	0	1	1	**2**	0	0	0	0	**3**	0	0	0	0	**1**
Tiping	Quthing	**M**	2.52	1	0	0	0	0	0	0	1	1	**4**	0	0	0	0	**3**	0	0	0	0	**1**
Tiping	Thaba-Tseka	**M**	22.86	7	0	0	0	0	0	0	1	1	**8**	0	0	1	1	**6**	0	0	1	1	**4**
Tiping	Mohale's Hoek	**M**	6.52	2	0	0	3	3	0	0	0	0	**5**	0	0	1	1	**4**	0	0	0	0	**6**
Tjotjong	Quthing	**M**	0.15	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**4**	0	0	1	1	**6**
Tlaling	Mohale's Hoek	**M**	1.37	1	0	0	0	0	0	0	1	1	**2**	0	0	1	1	**8**	0	0	1	1	**4**
Tlaling Ha Moena	Mokhotlong	**S**	0.36	1	0	0	1	1	0	0	1	1	**4**	0	0	1	1	**3**	0	0	1	1	**6**
Tlokoeng	Mohale's Hoek	**M**	5.19	2	0	0	0	0	0	0	0	0	**3**	0	0	1	1	**3**	0	0	0	0	**4**
Tlokoeng	Mohale's Hoek	**M**	0.52	1	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**3**	0	0	1	1	**5**
Tlokoeng	Maseru	**M**	1.93	1	0	0	1	1	0	0	1	1	**1**	0	0	1	1	**2**	0	0	1	1	**7**
Tlokotsing	Thaba-Tseka	**M**	5.05	2	1	1	1	1	0	0	1	1	**5**	0	0	1	1	**3**	0	0	1	1	**5**
Tolobanka	Mohale's Hoek	**M**	17.24	5	0	0	1	1	0	0	1	1	**7**	0	0	0	0	**1**	0	0	0	0	**3**
Tonamela Ha Sechache	Qacha's Nek	**M**	0.54	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	**1**
Topa	Mohale's Hoek	**M**	8.70	3	0	0	0	0	0	0	0	0	**4**	0	0	0	0	**3**	0	0	1	1	**1**
Topa	Quthing	**S**	0.56	1	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**5**	0	0	0	0	**1**
Topa	Qacha's Nek	**M**	7.11	2	0	0	1	1	0	0	1	1	**3**	0	0	1	1	**6**	0	0	0	0	**5**
Topa Ha Nkuebe	Qacha's Nek	**M**	3.62	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**4**	0	0	0	0	**1**
Tosing	Maseru	**M**	7.98	3	0	0	1	1	0	0	1	1	**5**	0	0	0	0	**1**	0	0	1	1	**4**

Village Name	District	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Tsatsa-Lemeno Ha Chaka	Maseru	**M**	3.62	1	0	0	0	0	0	0	0	0	**1**	1	2	0	0	**5**	0	0	0	0	**2**
Tsatsane	Mokhotlong	**M**	0.25	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	1	1	**7**
Tsehlong	Thaba-Tseka	**M**	9.05	3	2	2	2	2	0	0	0	0	**7**	0	0	1	1	**4**	0	0	1	1	**5**
Tseka	Quthing	**M**	25.68	7	0	0	1	1	0	0	1	1	**9**	0	0	1	1	**2**	0	0	1	1	**4**
Tsekong	Mokhotlong	**M**	1.55	1	0	0	1	1	0	0	0	0	**2**	0	0	0	0	**4**	0	0	1	1	**3**
Tsekong	Mohale's Hoek	**M**	0.60	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**5**	0	0	0	0	**7**
Tsekong Ha Lekhetho	Mokhotlong	**M**	1.57	1	0	0	0	0	0	0	1	1	**2**	0	0	1	1	**8**	0	0	1	1	**3**
Tsekong Ha Taelo	Berea	**M**	0.08	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	**1**	0	0	0	0	**1**
Tsenekeng Ha Mahab	Quthing	**M**	7.23	2	0	0	1	1	0	0	0	0	**3**	0	0	0	0	**2**	0	0	0	0	**3**
Tsepong	Quthing	**M**	23.22	7	0	0	0	0	0	0	1	1	**8**	0	0	0	0	**1**	0	0	1	1	**4**
Tsereoane	Berea	**M**	1.68	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**1**	0	0	1	1	**6**
Tsethe	Berea	**M**	1.49	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	1	1	**3**
Tsieng	Mokhotlong	**M**	19.56	6	2	2	3	3	0	0	0	0	**11**	2	4	1	1	**7**	0	0	0	0	**3**
Tsieng	Maseru	**M**	3.79	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**8**	0	0	1	1	**8**
Tsikoane	Mokhotlong	**M**	4.80	2	0	0	1	1	0	0	1	1	**4**	0	0	0	0	**4**	0	0	1	1	**3**
Tsitsa	Mohale's Hoek	**M**	13.68	4	0	0	0	0	0	0	1	1	**5**	0	0	0	0	**2**	0	0	0	0	**1**
Tsoana-Makhulo	Berea	**M**	6.80	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**10**	0	0	0	0	**2**
Tsoenyane Ha Rantelali	Thaba-Tseka	**M**	5.43	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**4**	0	0	0	0	**1**
Tsopholing	Leribe	**M**	2.87	1	0	0	0	0	0	0	0	0	**1**	1	2	1	1	**5**	0	0	0	0	**2**

Village Name	**District**	Nearest Road (Major (M) / Secondary (S))	Distance to nearest road (km)	Rank (0 – 8)	Mean duration of snow cover on nearest road per annum (days)	Rank (0 – 8)	Maximum duration of snow cover on nearest road (days)	Rank (0 – 8)	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Early Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Mid Season Vulnerability Ranking (0 – 40)**	Mean duration of snow cover per annum (days)	Rank (0 – 8)	Maximum duration of snow cover (days)	Rank (0 – 8)	**Late Season Vulnerability Ranking (0 – 40)**
Tsuinyane Ha Senyane	Qacha's Nek	**M**	0.81	1	0	0	0	0	0	0	0	0	**1**	0	0	1	1	**5**	0	0	0	0	**1**
Tuke	Quthing	**M**	0.97	1	0	0	0	0	0	0	0	0	**1**	0	0	0	0	**2**	0	0	1	1	**4**
Tumahole Ha Mothae	Quthing	**M**	3.88	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**3**	0	0	0	0	**4**
Vuka-Mosotho Ha Manti	Mafeteng	**M**	4.55	2	0	0	0	0	0	0	0	0	**2**	0	0	1	1	**4**	0	0	1	1	**4**
Waterfall	Mafeteng	**M**	10.79	3	0	0	1	1	0	0	0	0	**4**	0	0	0	0	**1**	0	0	1	1	**3**
Waterfall	Qacha's Nek	**M**	10.47	3	0	0	1	1	0	0	0	0	**4**	0	0	0	0	**2**	0	0	1	1	**4**
Zibandayo	Mafeteng	**M**	4.84	2	0	0	0	0	0	0	0	0	**2**	0	0	0	0	**2**	0	0	1	1	**5**

Appendix 2

Regional Vulnerability Maps of Villages in Lesotho

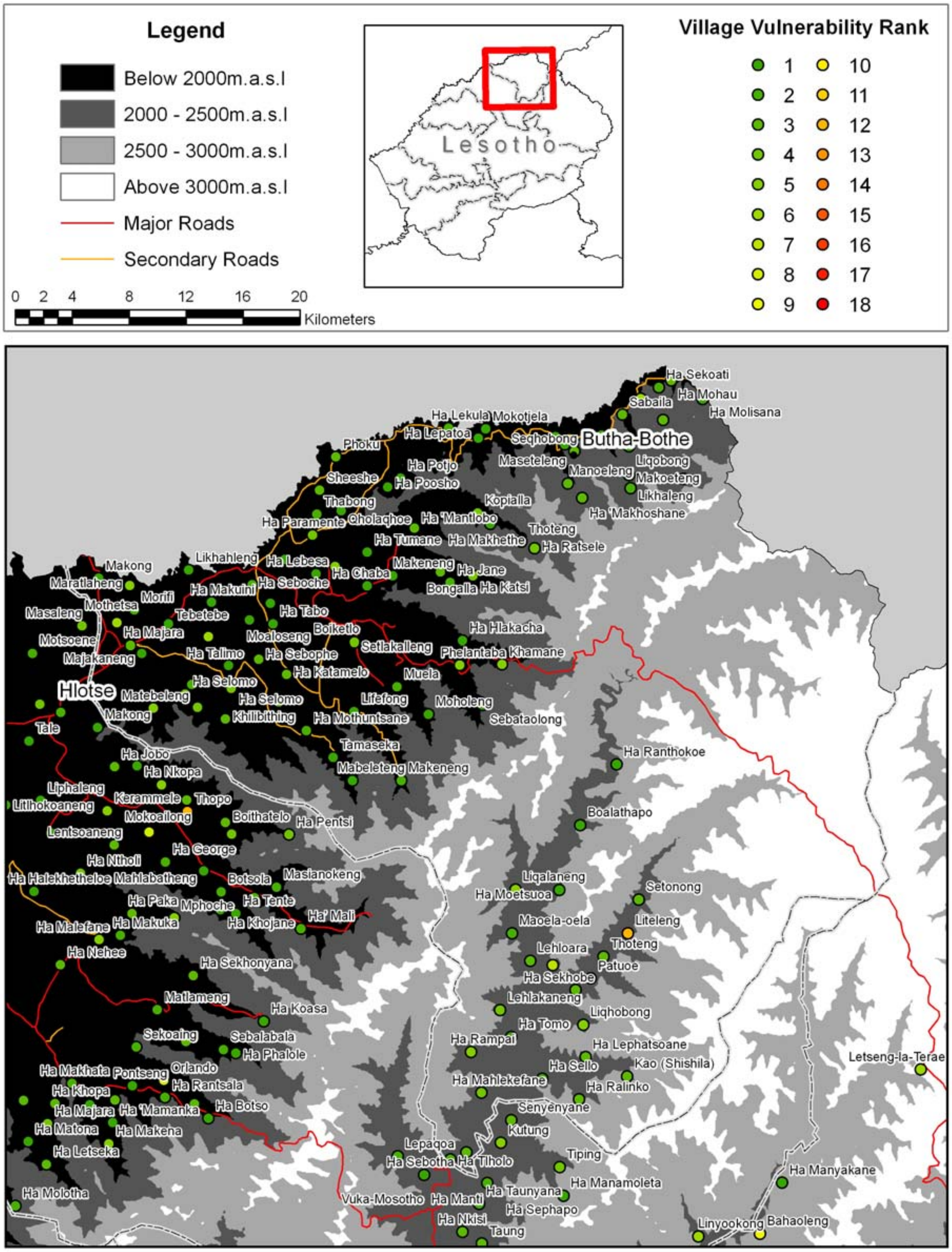

Figure (1): Early season vulnerability in the Butha - Buthe region.

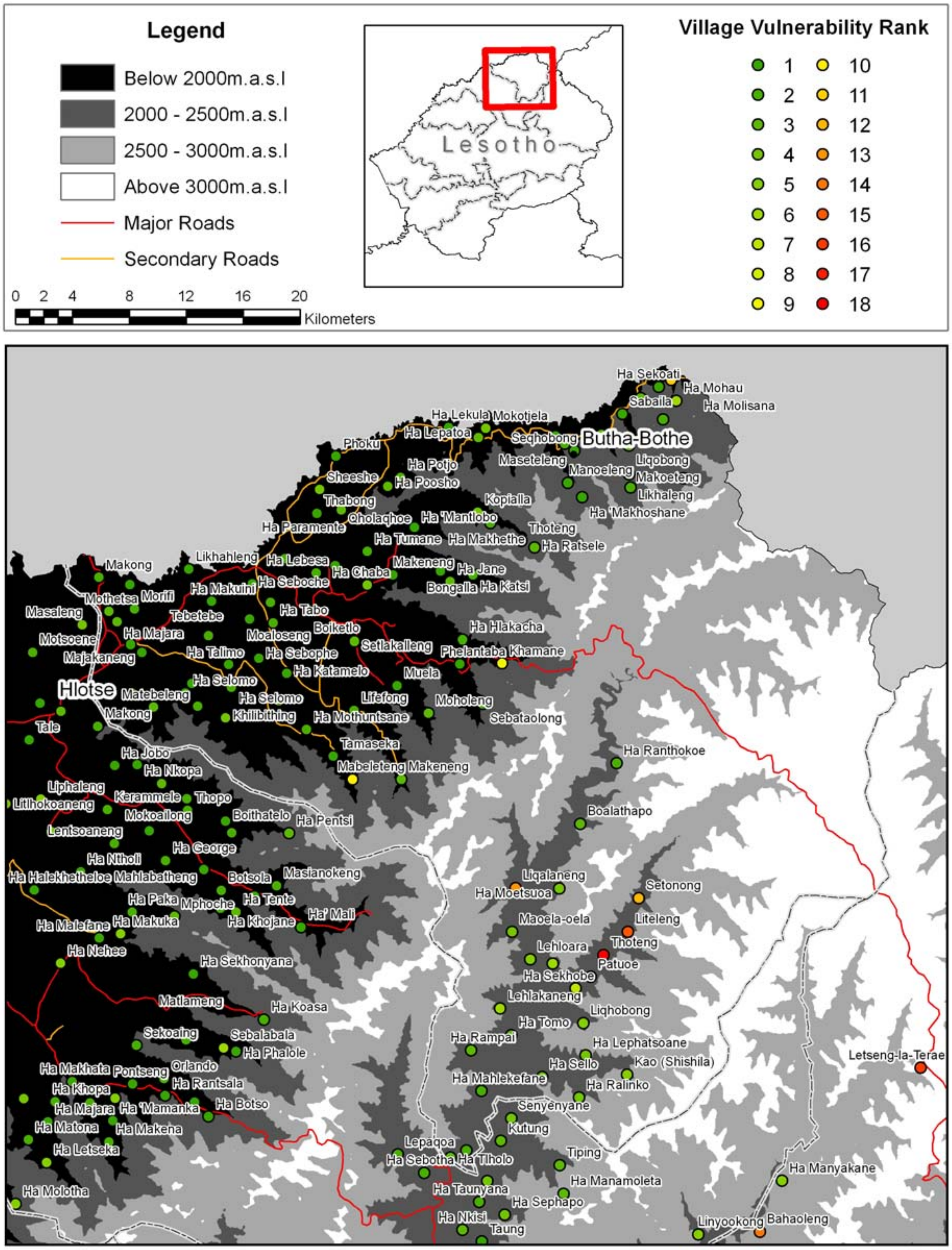

Figure (2): Mid season vulnerability in the Butha - Buthe region.

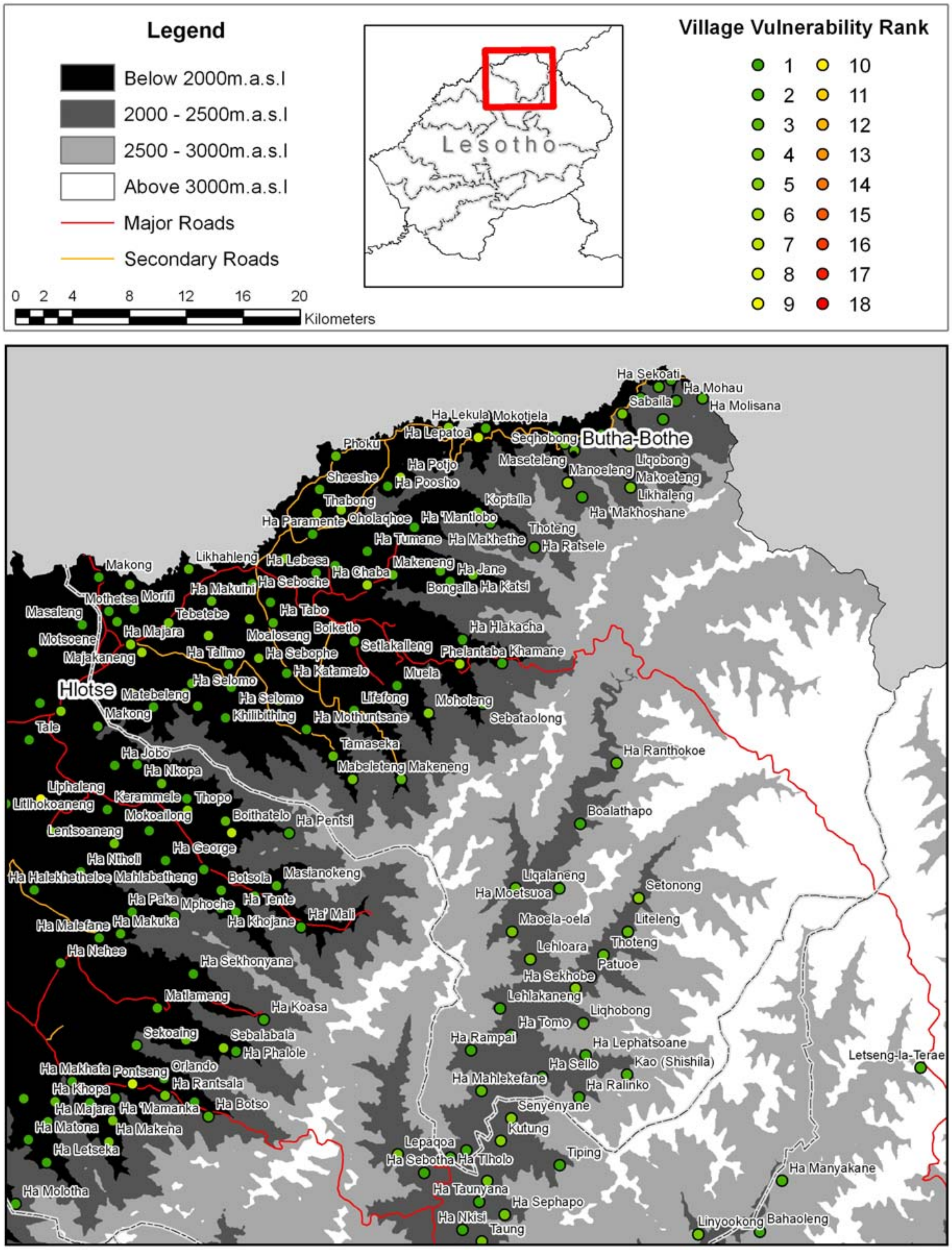

Figure (3): Late season vulnerability in the Butha - Buthe region.

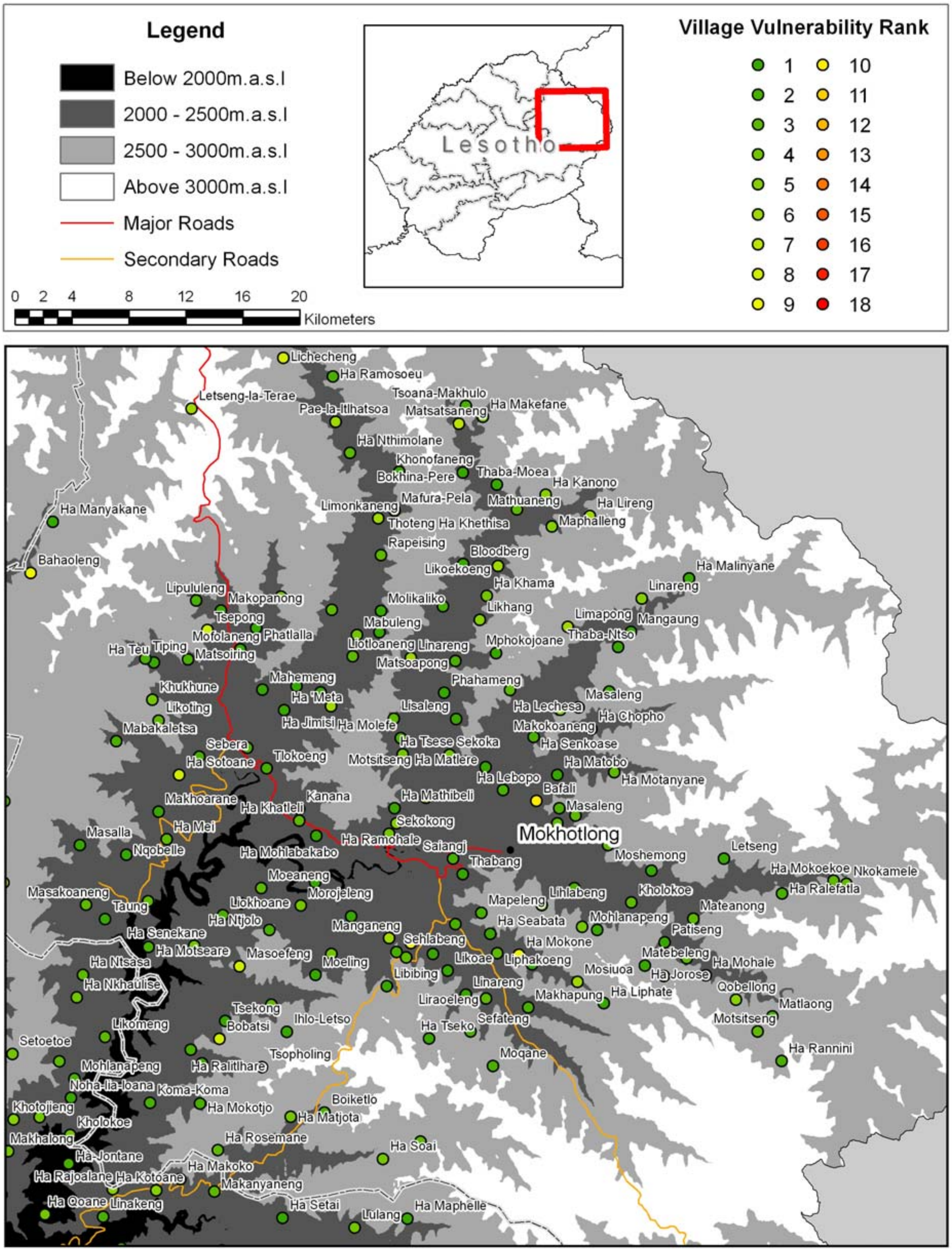

Figure (4): Early season vulnerability in the Mokhotlong region.

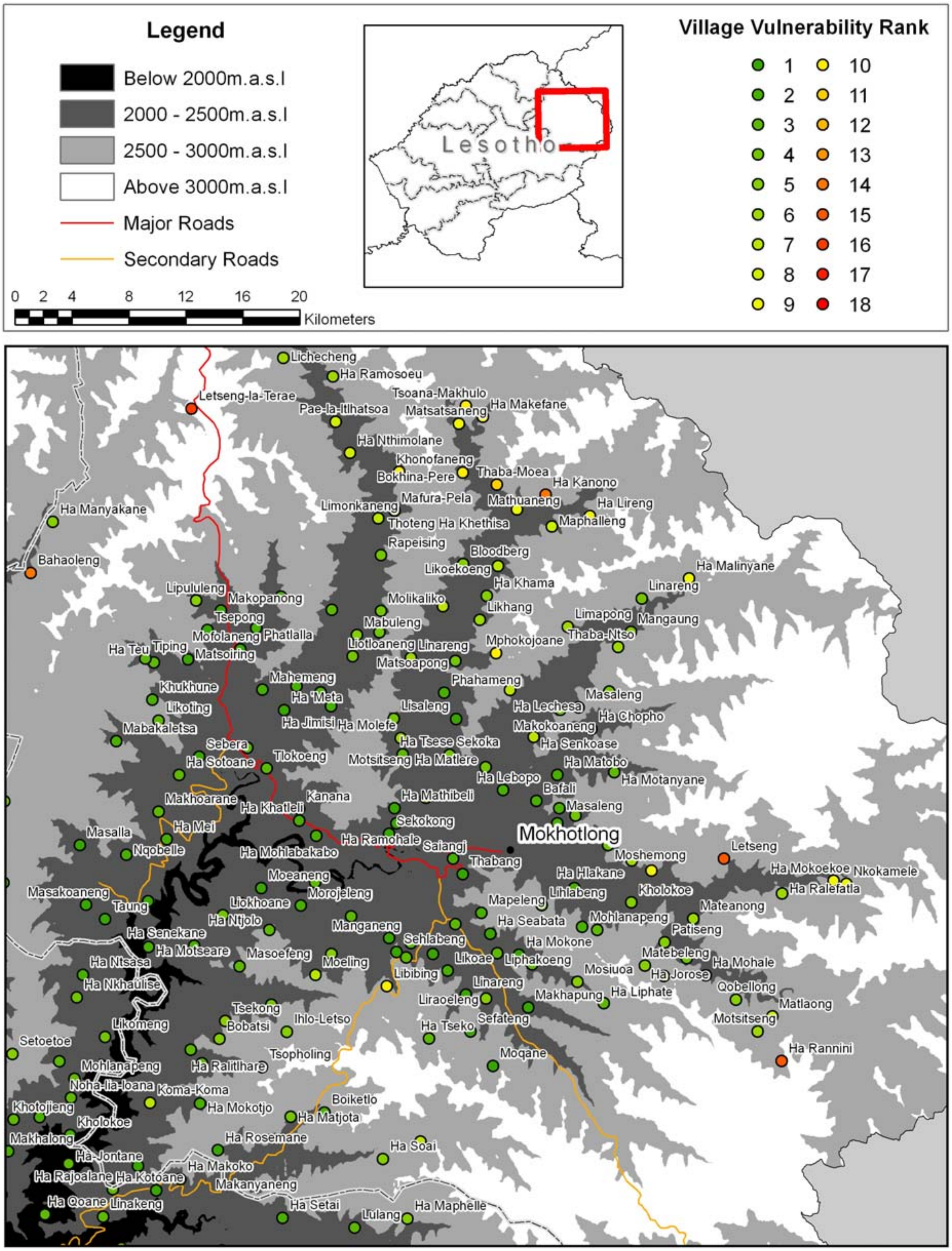

Figure (5): Mid season vulnerability in the Mokhotlong region.

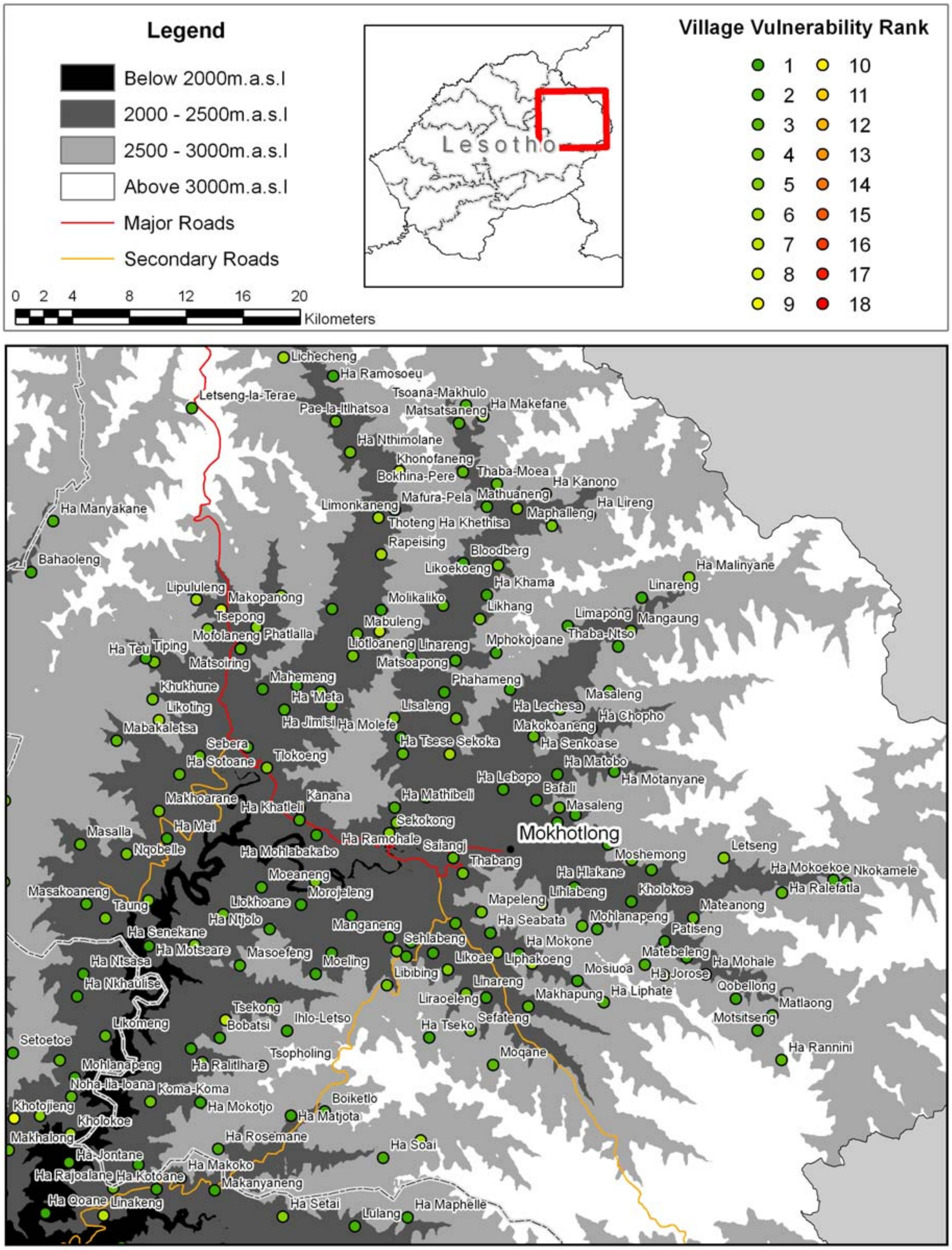

Figure (6): Late season vulnerability in the Mokhotlong region.

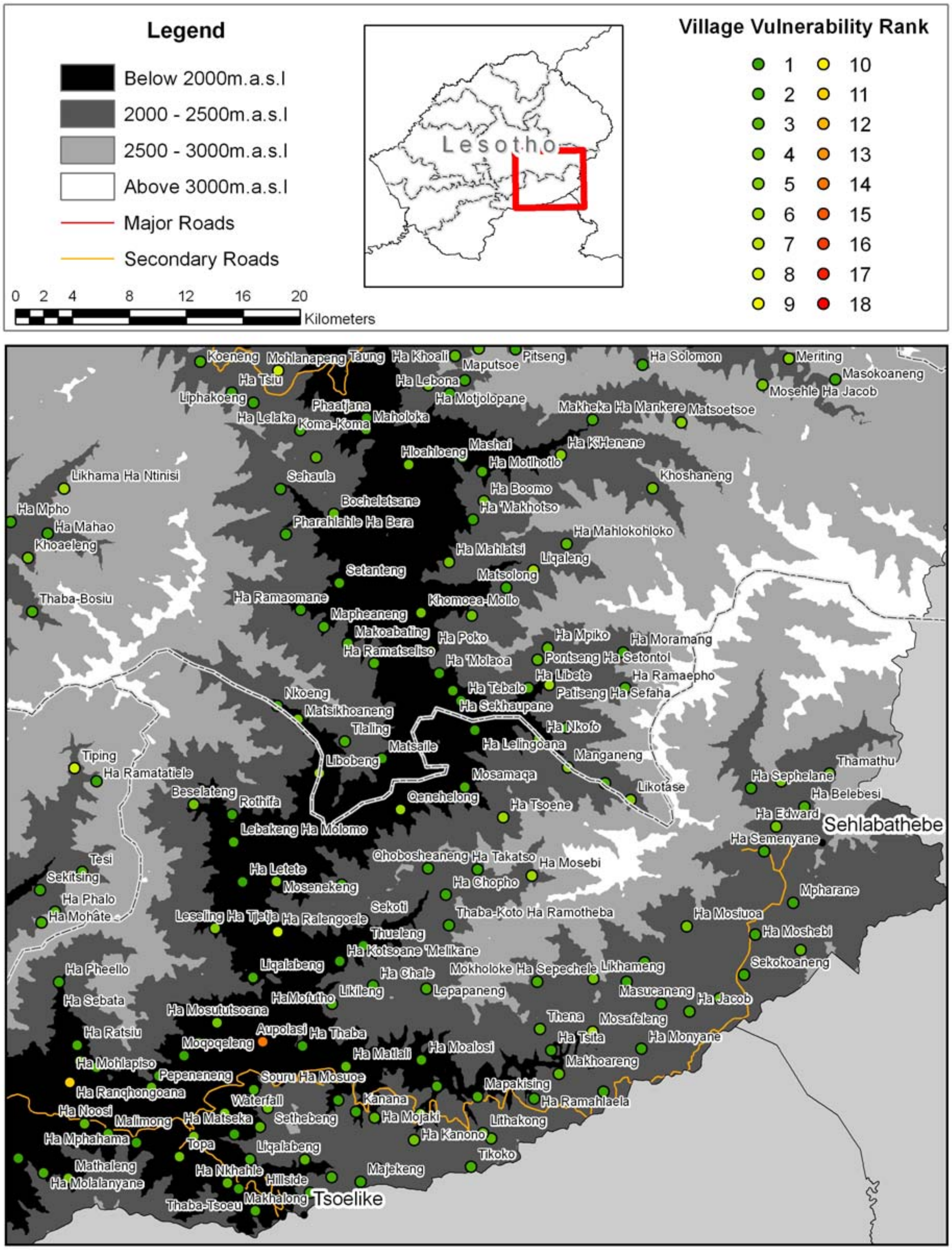

Figure (7): Early season vulnerability in the Sehlabathebe region.

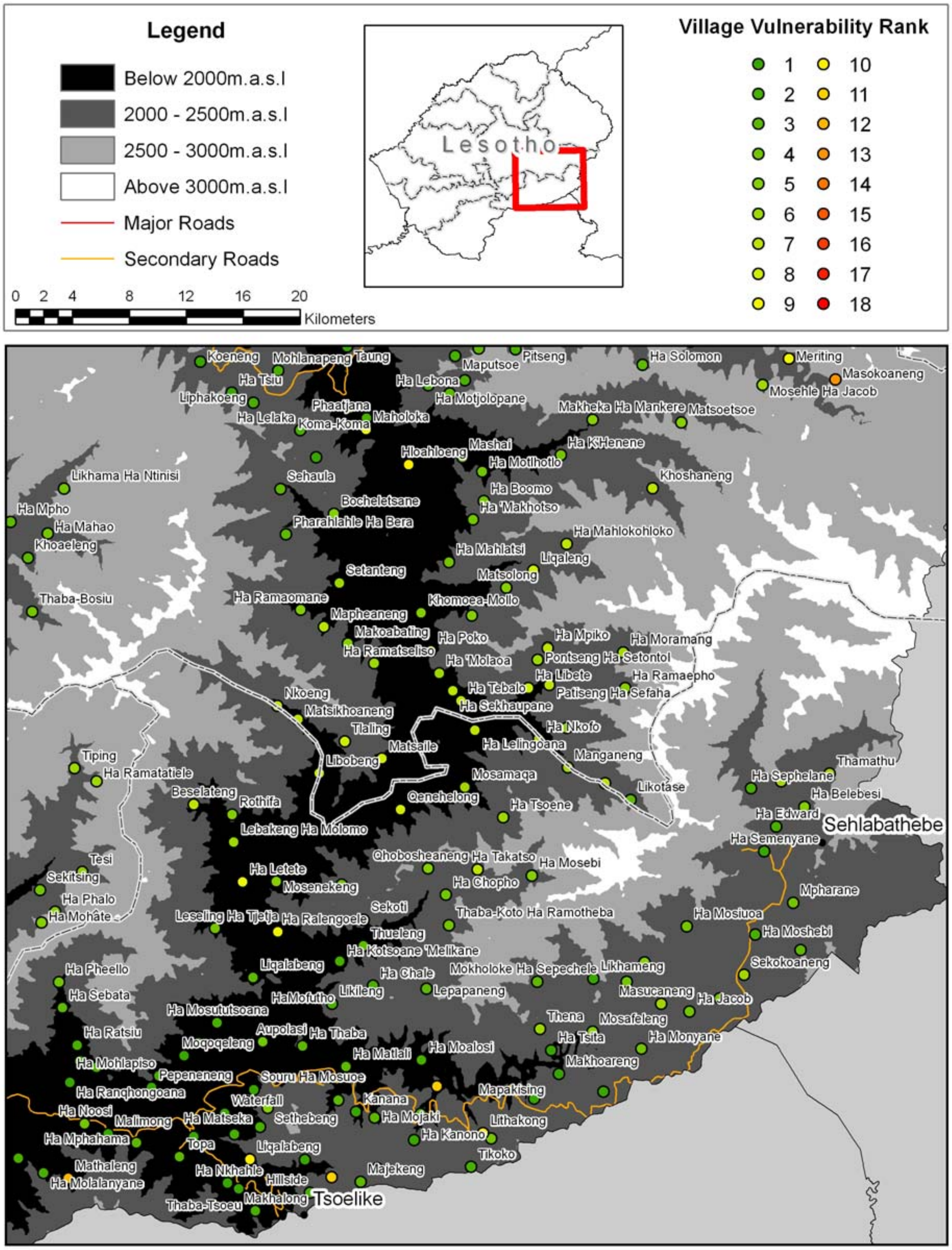

Figure (8): Mid season vulnerability in the Sehlabathebe region.

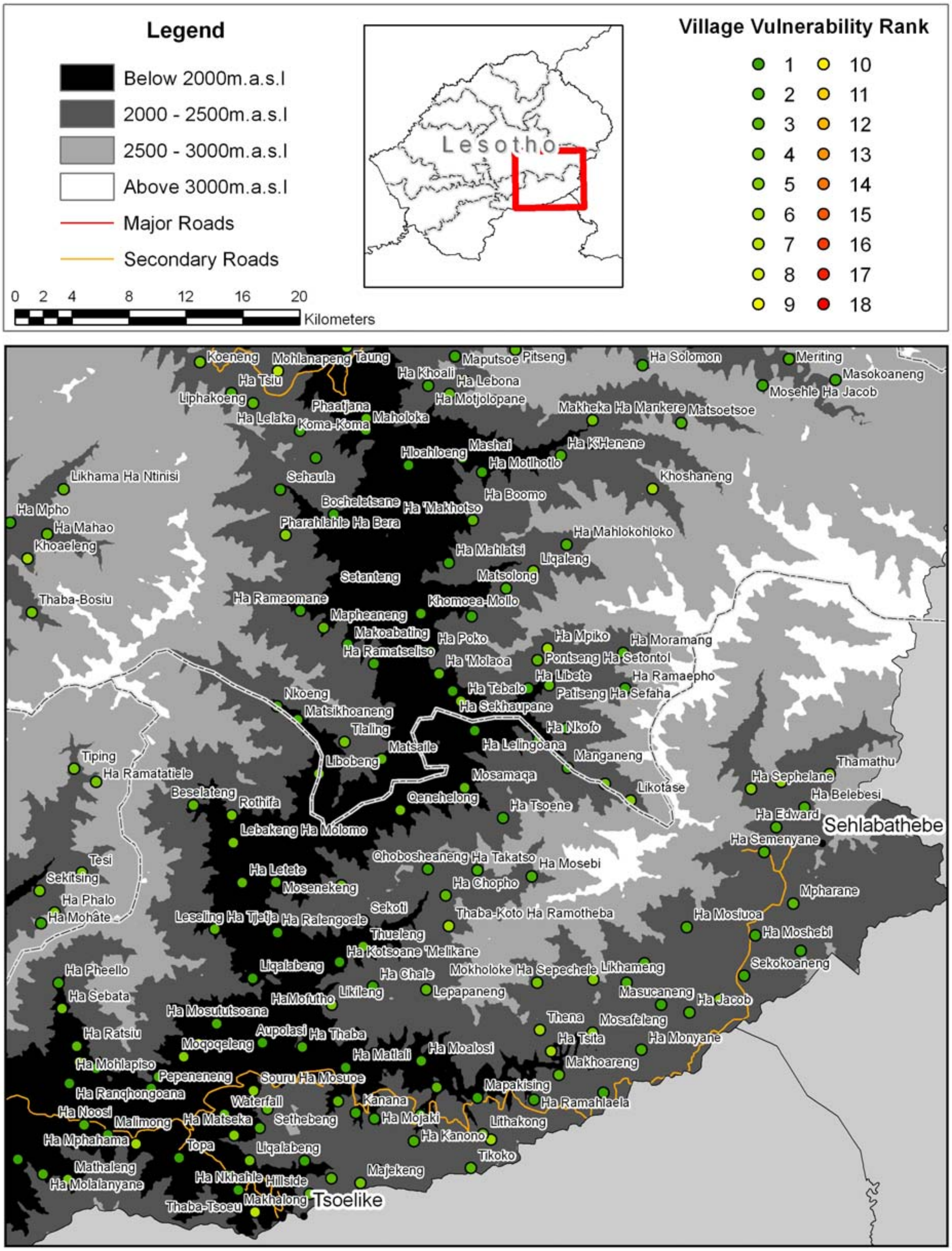

Figure (9): Late season vulnerability in the Sehlabathebe region.

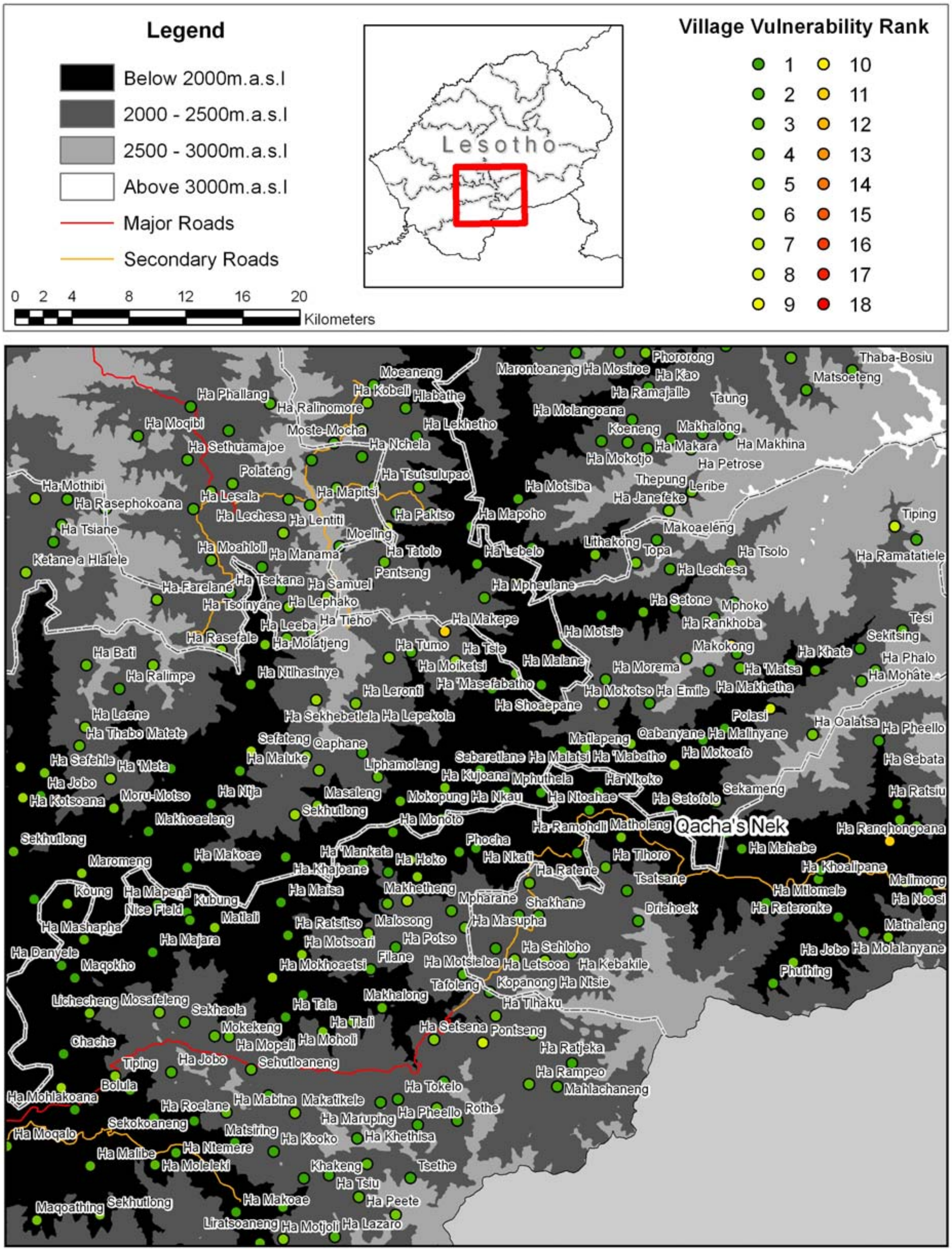

Figure (10): Early season vulnerability in the Qacha's Nek region.

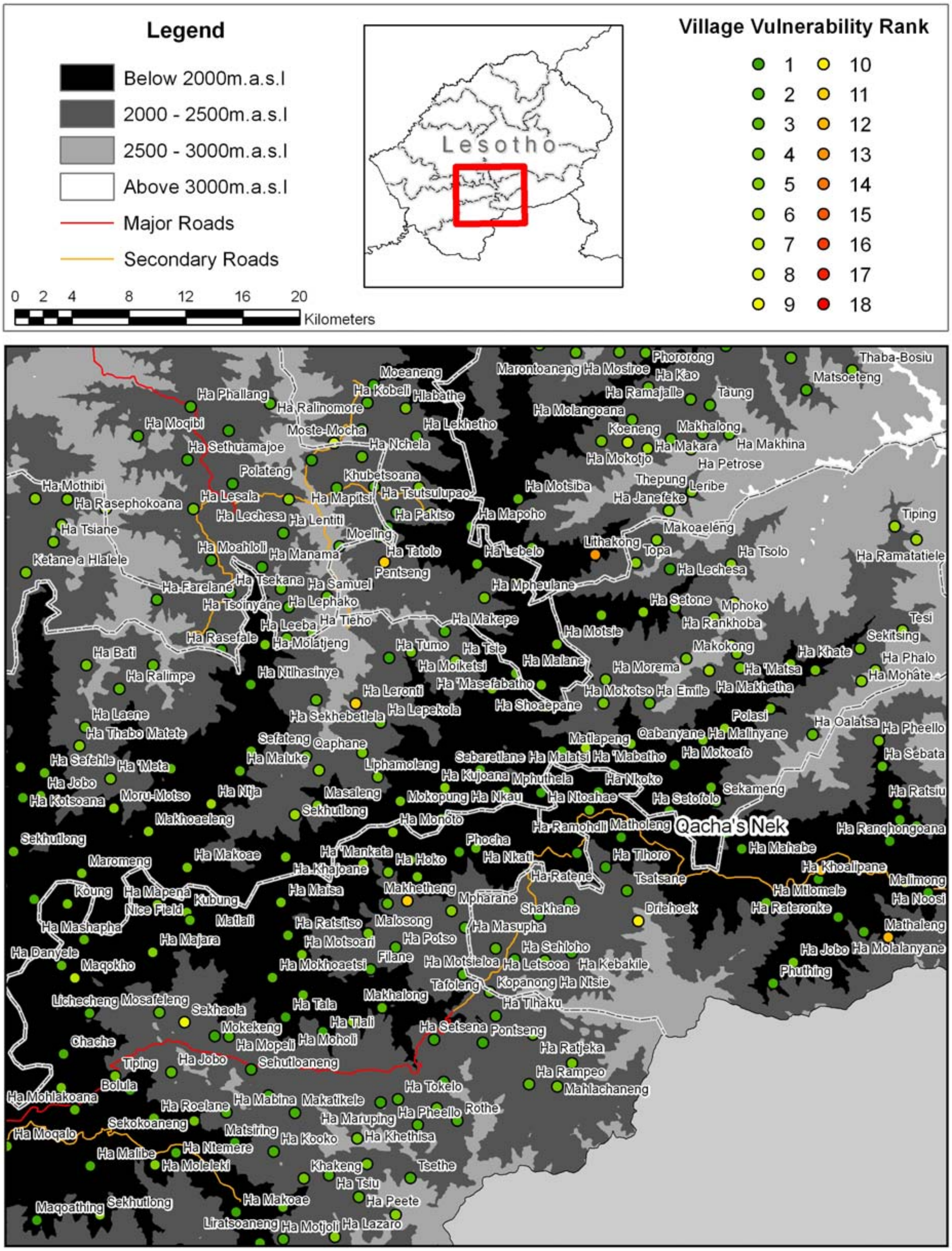

Figure (11): Mid season vulnerability in the Qacha's Nek region.

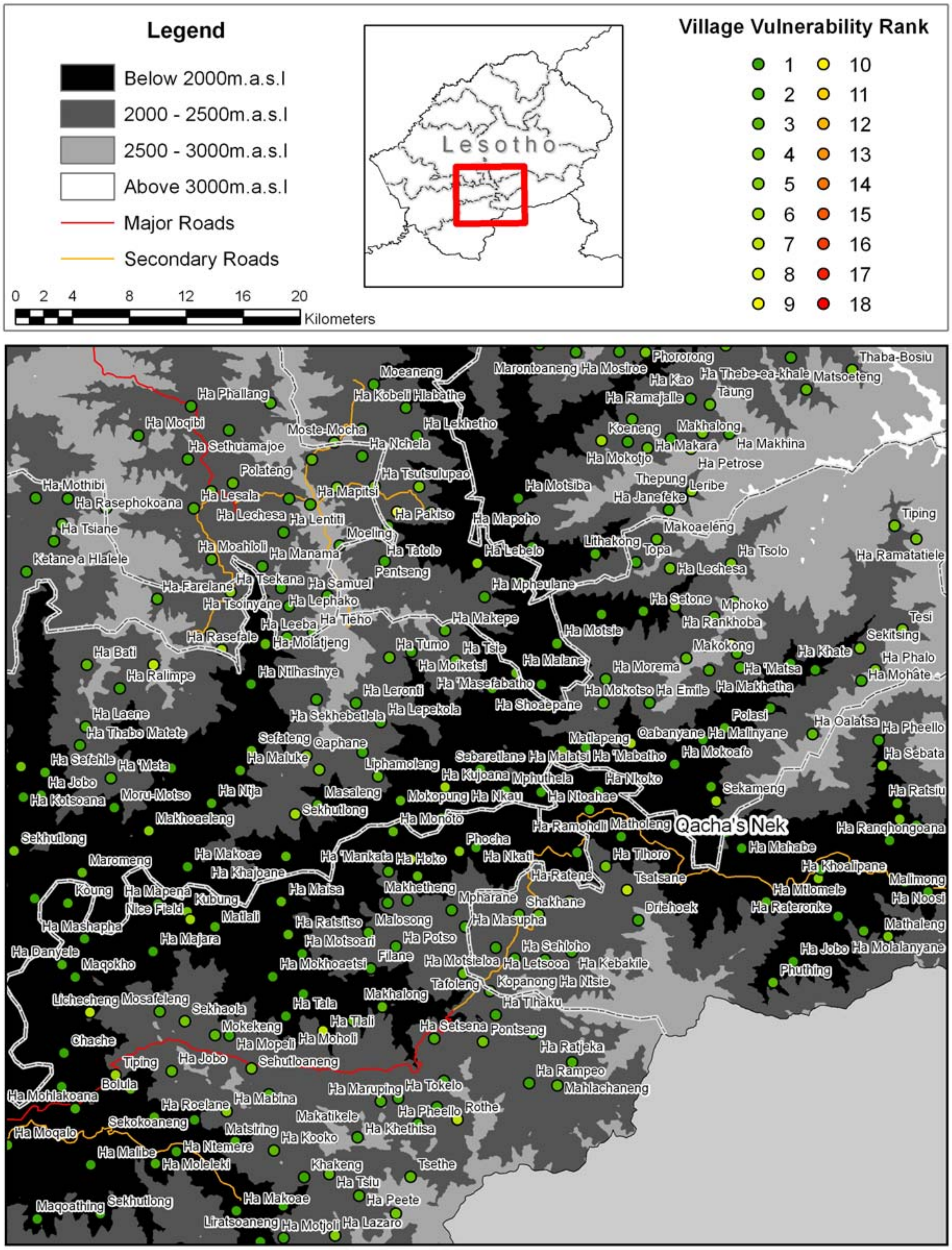

Figure (12): Late season vulnerability in the Qacha's Nek region.

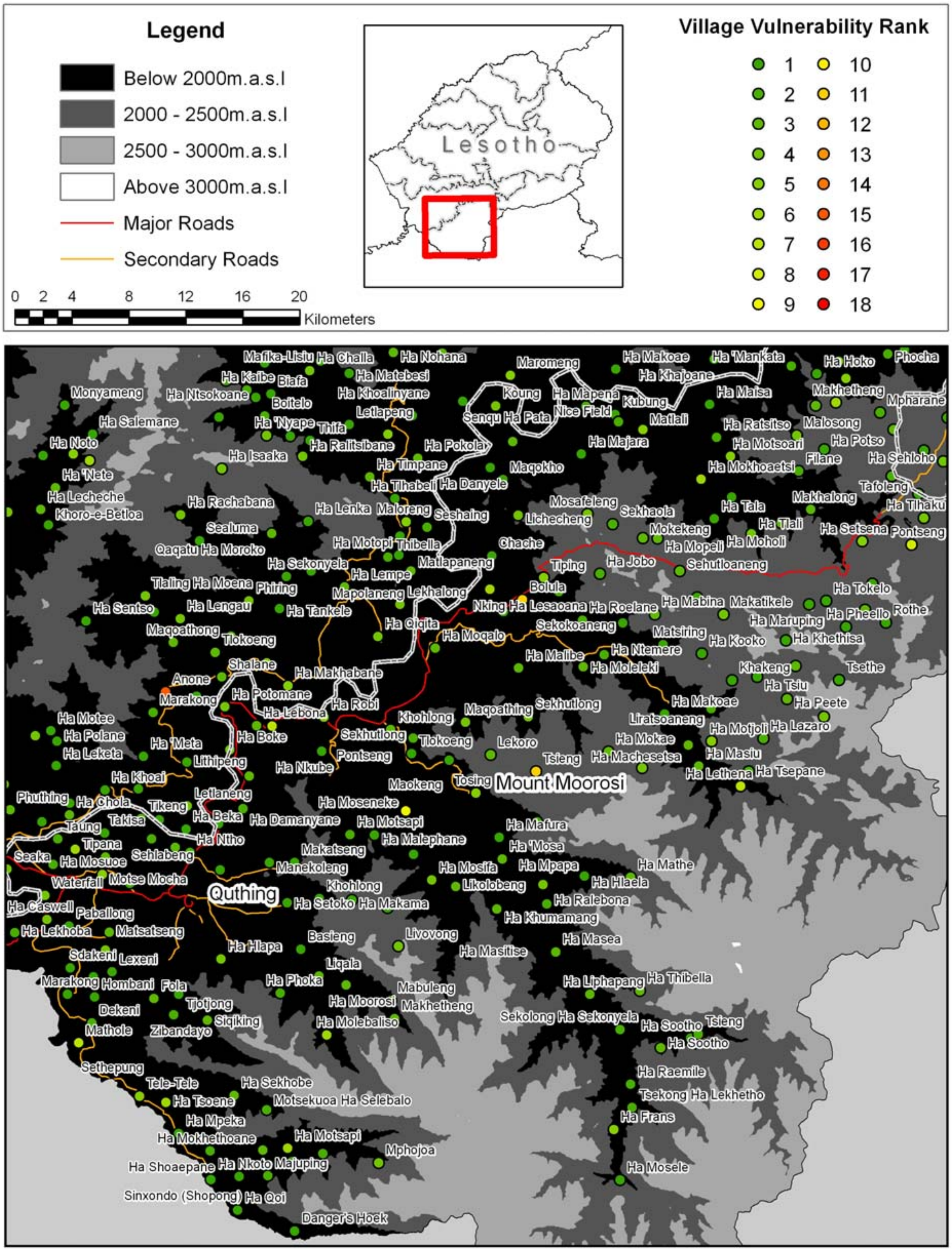

Figure (13): Early season vulnerability in the Mount Moorosi region.

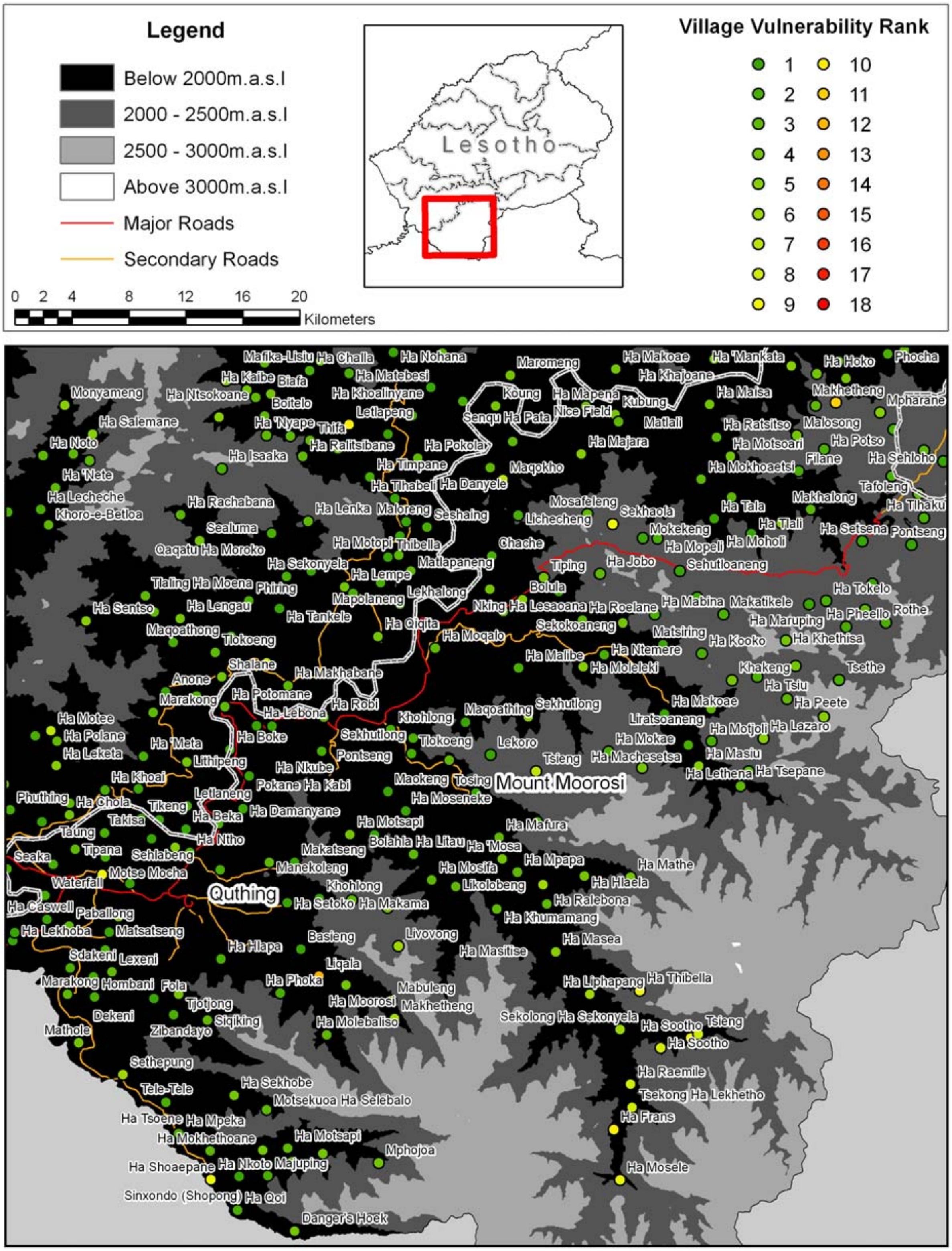

Figure (14): Mid season vulnerability in the Mount Moorosi region.

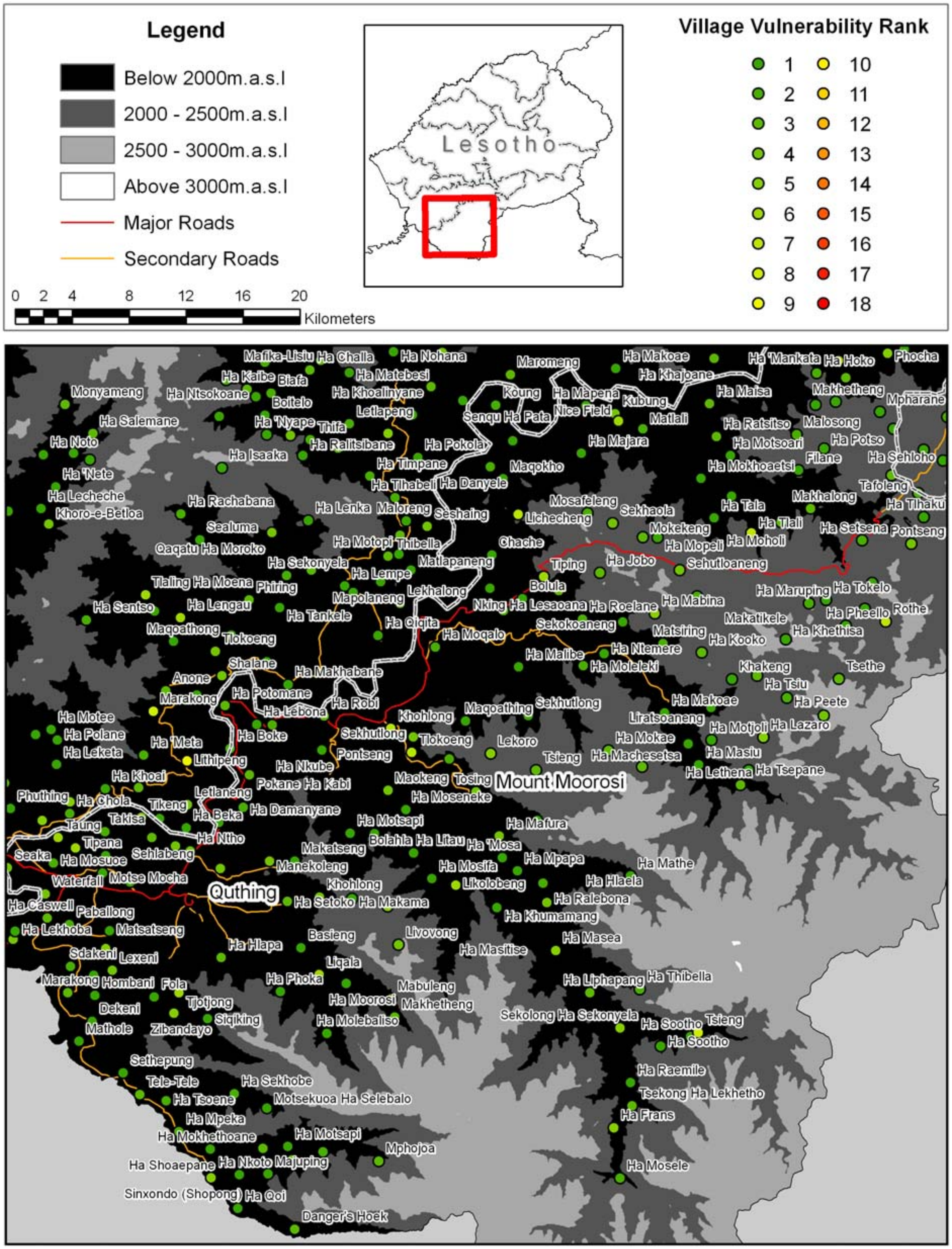

Figure (15): Late season vulnerability in the Mount Moorosi region.

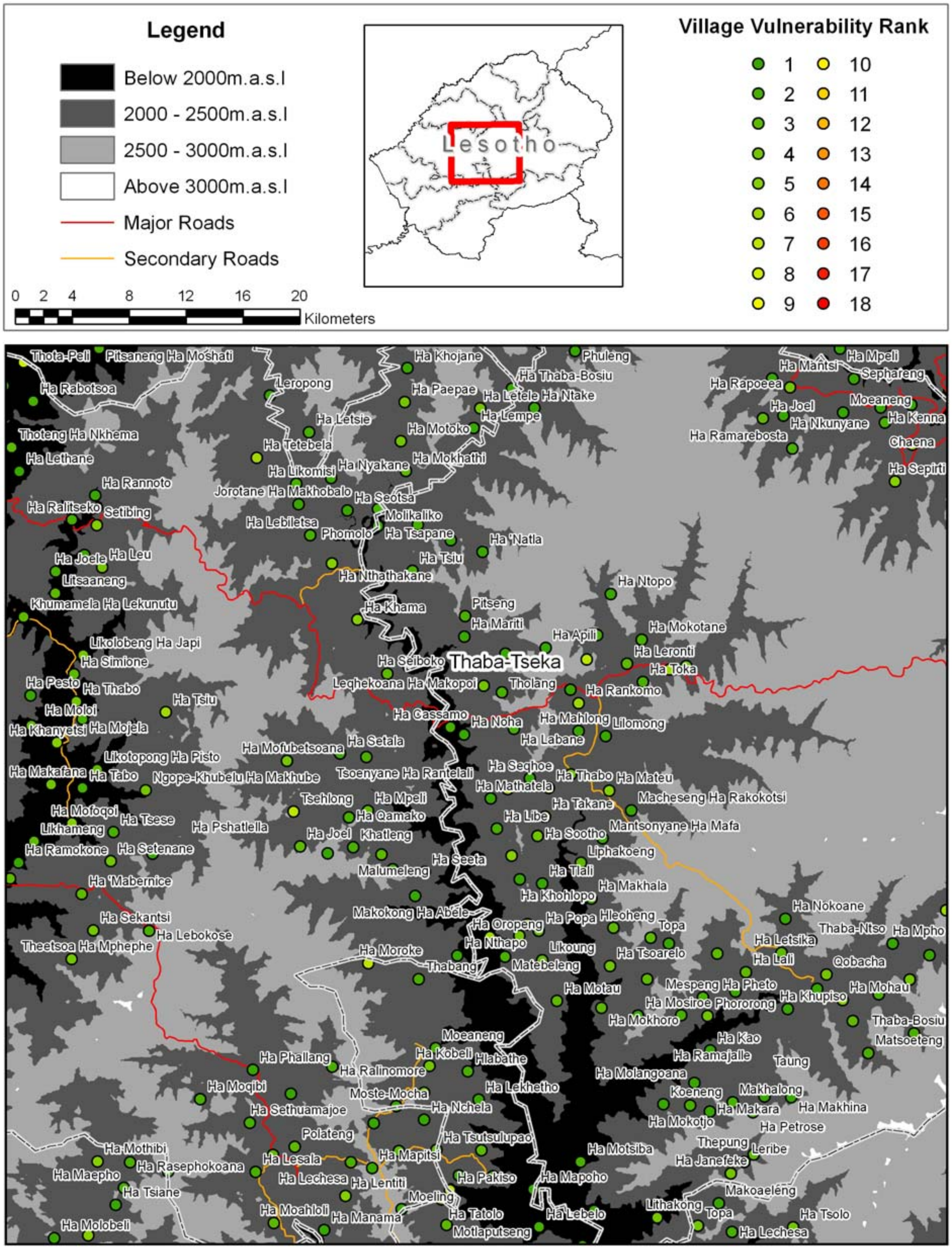

Figure (16): Early season vulnerability in the Thaba-Tseka region.

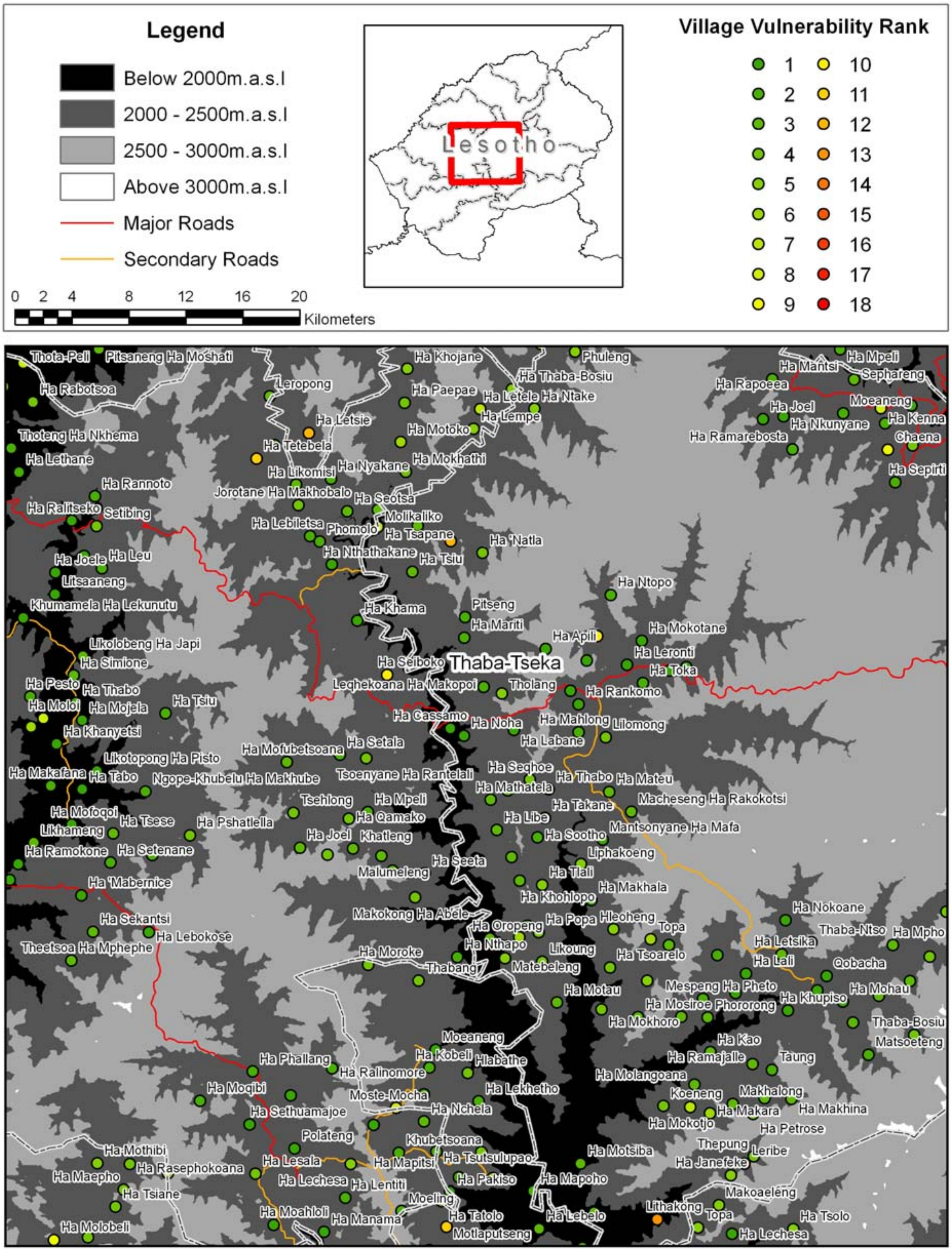

Figure (17): Mid season vulnerability in the Thaba-Tseka region.

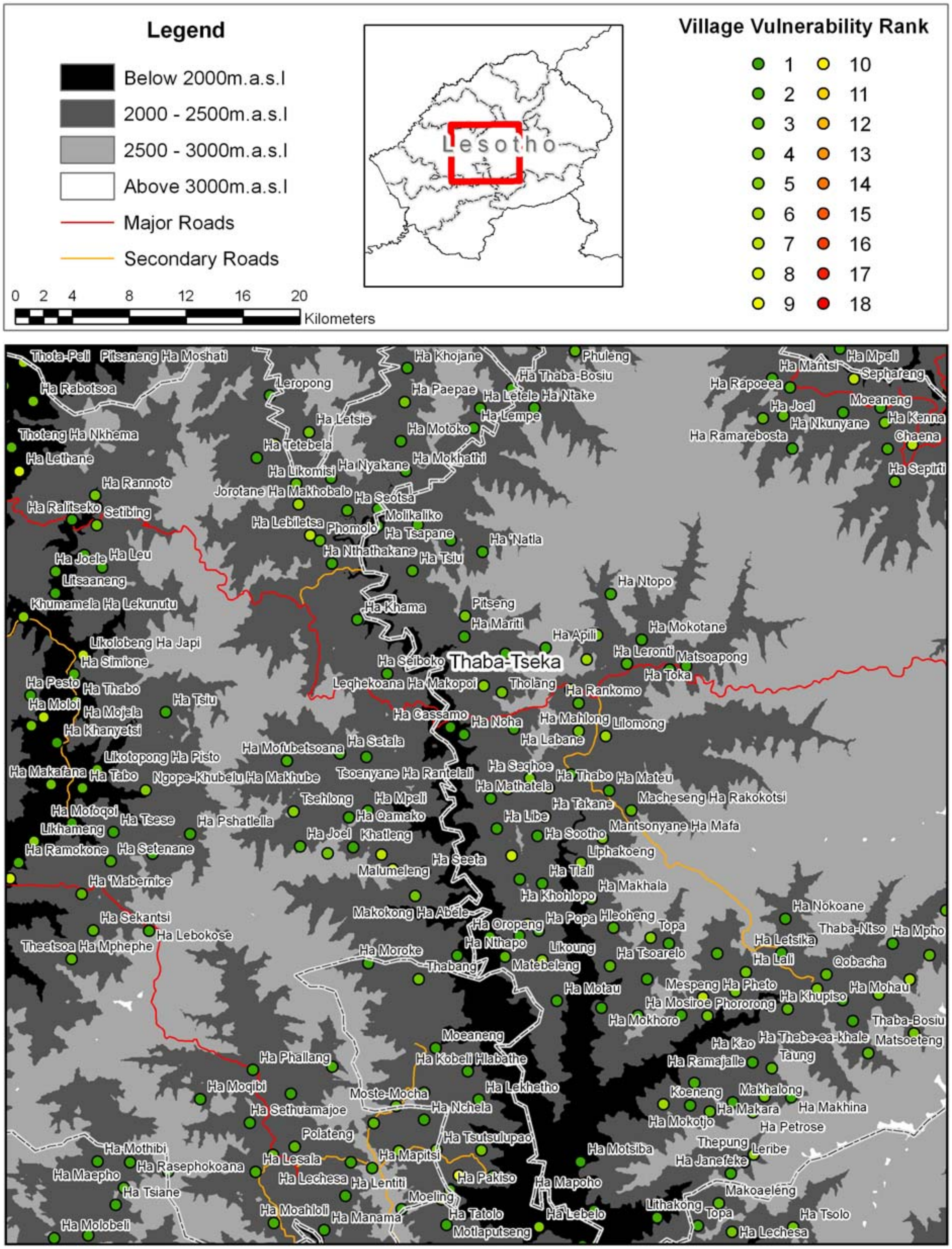

Figure (18): Late season vulnerability in the Thaba-Tseka region.