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Assessment of Social Vulnerability to Natural Hazards in the Mountain Kingdom of Lesotho

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Lesotho's landlocked mountainous setting with thin regolith cover and poor economic situation make it vulnerable to hazardous events associated with climate such as drought, floods, strong winds, heavy snowfall, and severe

frost. To date, no quantitatively based vulnerability assessment has been undertaken in this heavily populated, developing region in southern Africa. The primary aim of this study was to assess social vulnerability of communities to natural hazards by applying a place-based social vulnerability index developed for the United States, to the Lesotho context.

The study used 2006 Lesotho census data, district government records, and household interviews to identify 27 indicators of social vulnerability in southern Lesotho, and then used principal components analysis to generate a social vulnerability index for the study region. Index scores were summed and then mapped to quantify spatial variability in social vulnerability. The study results show a clustering of highly vulnerable communities in the rural highlands as a result of underdevelopment, poverty, and inaccessibility.

Keywords: Natural hazards; social vulnerability; place-based vulnerability; mountains; Lesotho.

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Introduction

Considerable attention has been paid to the vulnerability of developing and landlocked countries to climate change and associated natural hazards (UN-OHRLS 2009; Karki and Gurung 2012). Article 4 of the United Nations Framework Convention on Climate Change requires parties to give full consideration to meeting the needs and concerns of developing countries arising from the adverse effects of climate change. Of particular interest are landlocked countries with fragile and mountainous ecosystems (UNFCCC 2011; UNOHRLLS 2014).

Lesotho is a small (30,588 km²), mountainous, and landlocked country and one of the least developed countries in the world; it is prone to natural hazards, its fragile ecosystems are regarded as highly vulnerable to climate change (Matarira 2008; Gwimbi et al 2012; Matarira et al 2013; UNDP 2014). Natural hazards in Lesotho, which include floods, drought, frost, strong winds, and heavy snowfall, have caused many human and livestock deaths as well as damage to property and loss of crops (Grab and Nash 2010; Matarira et al 2013; Grab and Linde 2014).

The impacts of natural hazards are exacerbated in many mountain areas; more than 70% of Lesotho's population lives in remote and ecologically fragile mountainous terrain. The importance of understanding the social dynamics of vulnerability in mitigating natural hazards has been acknowledged by the Lesotho

government (DMA 2010; Gwimbi et al 2012). However, while some studies have focused on vulnerability to food insecurity (LVAC 2007, 2011; DMA 2012; Famine Early Warning Systems Network 2013), there has been no comprehensive institutionalized effort to assess social vulnerability to natural hazards. Although social vulnerability is considered a multidimensional construct, which is not easily defined by a single variable, it is generally viewed as a "measure of both the sensitivity of a population to natural hazards and its ability to respond to and recover from the impacts of hazards" (Cutter and Finch 2008: 2301). We focus on individual, family, and community vulnerability within various geographic subregions of southern Lesotho, but for ease of expression, henceforth we refer to such collective social vulnerability as that concerning the "community." Such an assessment is an important initial step toward understanding natural hazard risks, improving response capabilities, and supporting natural disaster prevention, mitigation, preparedness, and recovery programs.

This study was an attempt to quantify social vulnerability to natural hazards in southern Lesotho using a social vulnerability index methodology to assess the social factors and processes that make communities vulnerable and the spatial dynamics of that vulnerability. We incorporated indicators specific to Lesotho's context, which may also be applicable to other developing mountainous regions where data availability is a challenge. Adjustments in the selection of data and

input variables were required to fully capture the geography of Lesotho and the study area.

Study area and methods

Environmental setting

Lesotho is a mountainous yet densely populated (ca 1.9 million inhabitants), landlocked country within South Africa (Figure 1). It has 4 agro-ecological zones: lowlands (1400 to 1800 m above sea level [masl]), foothills (1800 to 2000 masl), the Senqu River Valley (1400 to 1800 masl), and highlands (2000 to 3482 masl); the highlands make up 70% of the country (LMS 2001). Lesotho has varied geomorphology and topography, including microclimatological influences, which have a significant impact on its ecology, livelihoods, and economy. Rainfall, most of which falls between October and April, varies between 700–1000 mm per year depending on location. The northern and eastern highlands are wettest, while the study region in southwestern Lesotho is driest (Sene et al 1998; Hydén 2002). Monthly mean minimum temperatures in winter range from about -6°C in the

highlands to 5°C in the lowlands; subzero temperatures occur during most nights in winter (mid-May to mid-August). In summer (November to February), mean maximum temperatures vary from 29°C in the lowlands to 16.5°C in the highlands (Wilken 1978; LMS 2005). Severe frosts and snowfalls are possible from May to September (Grab and Nash 2010; Moeletsi and Walker 2013; Grab and Linde 2014).

Several reports and authors have argued that the country has experienced increasing numbers of severe weather events during recent years, as measured by an increasing frequency of natural disasters (eg LMS 2002, 2010; Gwimbi et al 2012; Matarira et al 2013). Archival research has demonstrated that, between 1825 and 2012, human lives were occasionally lost, livestock was killed, crops were destroyed, and buildings and infrastructure were damaged or destroyed by severe weather (Eldredge 1987; Showers 2005; Grab and Nash 2010; Nash and Grab 2010). Heavy snowfall has been the most frequent hazard, followed by severe frost, drought, floods, and strong winds (Table 1).

Given Lesotho's highly varied topography and associated climate gradients, the spatial and temporal

FIGURE 1 Lesotho. (Map by Wendy Phillips and Stefan Grab)

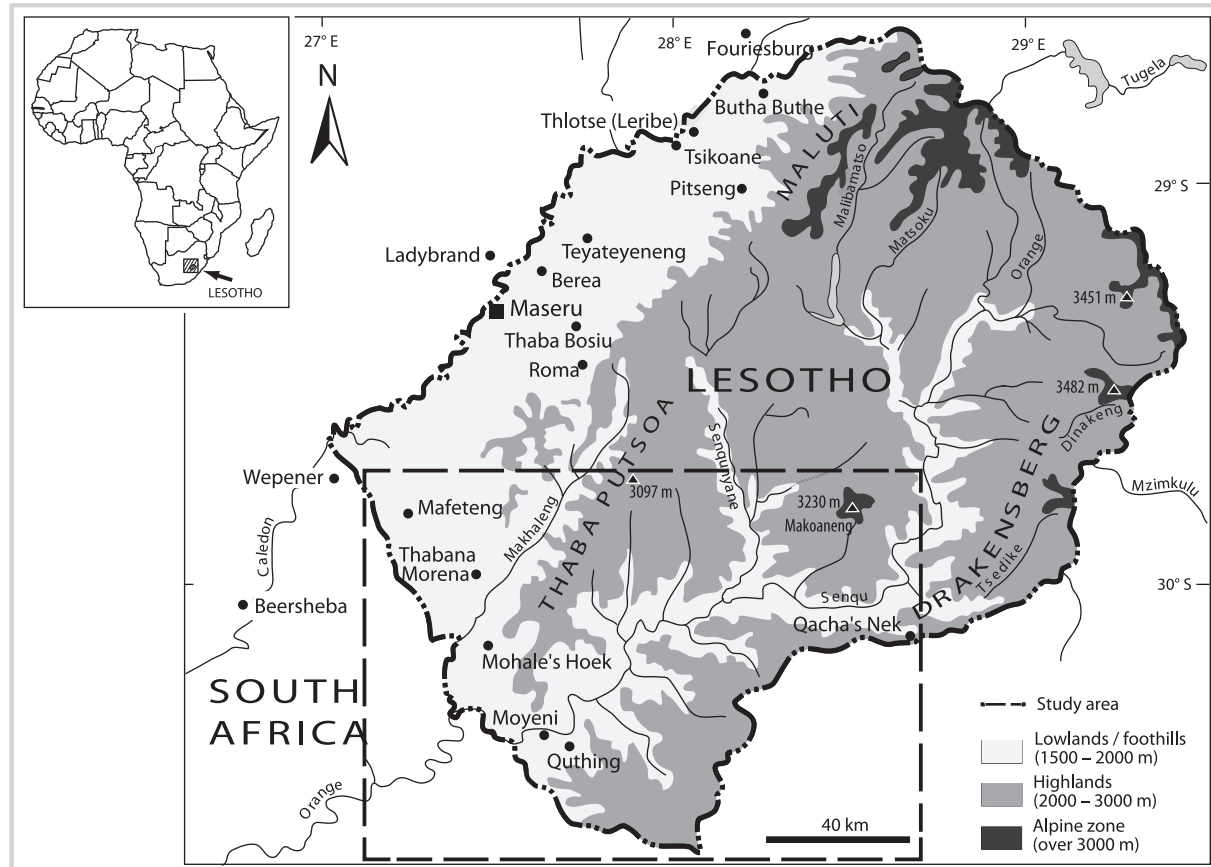


TABLE 1 Documented hazards and their average frequency in Lesotho, 1825–2012.

Hazard	Average frequency
Heavy snowfall	Every 3.1 years
Severe frost	Every 3.3 years
Drought	Every 3.5 years
Floods	Every 3.5 years
Strong winds	Every 4.8 years

occurrence of hazards is also varied, and so is their impact. While much of the country is vulnerable to natural hazards, some hazards (eg heavy snowfall, severe frost, and drought) are particularly prevalent in the study area (Figure 2). For instance, most villages located above 2700 masl are prone to heavy snowfall and prolonged snow cover (Grab and Linde 2014). Often, villages and settlements in the highlands are negatively impacted by snow, mainly because it isolates them from other parts of the country. The highlands have a weak agricultural and

natural resource base (due to mountainous terrain and unproductive soils) and suffer from inaccessibility and scarce income earning opportunities (Turner 2005; Sechaba Consultants 2006; One World 2009, 2010). Reliance on progressively lower-yielding subsistence agriculture, deteriorating pastures, and decreasing livestock health leads to deteriorating household income, assets, social status, and social support.

Administrative divisions

Lesotho is organized as a constitutional monarchy with 10 districts subdivided into 80 constituencies consisting of 129 community councils (village-based public representative bodies; KoL 2010). The kingdom is regulated by a dual legal system consisting of customary and general law. The study area focused on 2 geographically varied districts in southwestern Lesotho: Mohale's Hoek and Quthing ($30^{\circ}09'S$; $27^{\circ}28'E$ to $30^{\circ}24'S$; $27^{\circ}42'E$). Mohale's Hoek totals 8 constituencies and 14 community councils, while Quthing has 5 constituencies and 10 community councils (Table 2). Each community council consists of a number of villages.

FIGURE 2 Study area. (Map by Moipone Letsie)

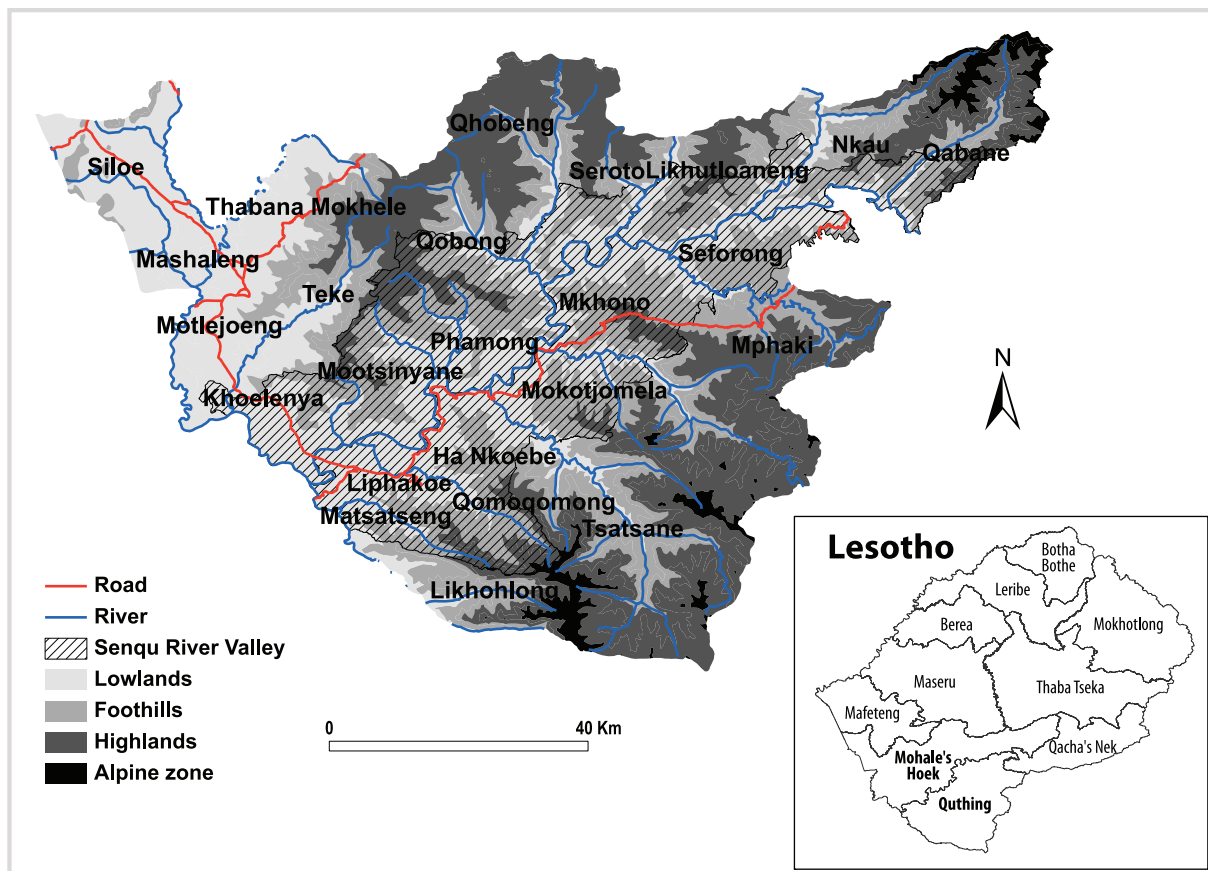


TABLE 2 Administrative divisions in the case study area.

Districts	Constituencies	Community councils (each consisting of a number of villages)
Mohale's Hoek	Hloahloeng	Likhutloaneng
		Nkau
		Qabane
	Ketane	Qhobeng
		Qobong
		Seroto
	Mekaling	Khoelenya
	Mohale's Hoek	Motlejoeng
	Mpharane	Thabana Mokhele
	Qaqatu	Mootsinyane
		Phamong
		Teke
	Qhalasi	Mashaleng
	Taung	Siloe
Quthing	Mount Moorosi	Mkhono
		Mokotjomela
	Moyeni	Liphakoe
		Qomoqomong
	Qhoali	Mphaki
		Seforong
	Sebapala	Ha Nkoebe
		Tsatsane
	Tele	Likhohlong
		Matsatseng

Source: BoS 2015

The study area's 2 districts and 24 community councils were used as the spatial units of analysis for this study. Community councils were the most appropriate unit of analysis because of the administrative structure in Lesotho, availability of demographic data, and the statistical requirements for the creation of the social vulnerability index (SoVI). Community councils constitute an entity whose residents share ideas, have similar livelihoods, values, and natural hazard risk culture. They are also meant to represent an area with a fairly homogenous population with respect to demographic

characteristics, economic status, and living conditions. Additionally, many government functions and decisions begin at the community council level.

Methodology

The study used both quantitative and qualitative methods, which allowed us to assess social vulnerability from different perspectives and integrate the viewpoints of different stakeholders. It relied on 2006 census data and the 2010 district information handbooks at the community council level, key informant interviews with the district disaster management offices, as well as 314 household interviews in the 24 community councils of the 2 districts studied (BoS 2015). We adopted a multistage sampling technique (Agresti and Finlay 2008), which included stratified sampling of respondents based on their geographical location, from the district level to the village level. A stratified random sampling technique was then employed at the village level to select respondents for household interviews and to ensure that the sample was representative.

The 27 social vulnerability variables chosen for the study were identified either from those mentioned in previous studies (Cutter et al 2003; see also Wood et al 2010; Dunno 2011; Yoon 2012; Chen et al 2013; Cutter and Morath 2013) or by disaster management officials in Lesotho. Most variables correspond to widely studied dimensions of social vulnerability: socioeconomic status, gender, education, age, unemployment, rural or urban location, special needs, housing conditions, family structure, occupation, and social dependency (Dunno 2011; Cutter and Morath 2013). Others were chosen for their relevance to the Lesotho context: access to roads, electricity, radios, mobile phones, toilets, and piped water.

Thus, we adapted a social vulnerability index (SoVI) originally developed by Cutter et al (2003) for the United States and applied it at the community council level in the 2 study districts. The SoVI provides an empirically based comparative measure that facilitates the geographic examination of relative levels of social vulnerability across space (Cutter et al 2003; Cutter and Morath 2013). It focuses mainly on the capacity of a population to prepare for, mitigate, respond to, and recover from natural disasters.

All the variables were normalized using percentage, density, or per capita (per km²) functions, then variables were standardized using z-scores standardization. This generates variables with a mean of 0 and standard deviation of 1 (Cutter et al 2003; Yoon 2012). The variables were then input into the Statistical Package for Social Sciences (SPSS) to carry out a principal components analysis, which reduced the 27 variables into 8 multidimensional components explaining 80.95% of the variance. The PCA produced a minimum number of components that adequately accounted for the covariation among the larger number of analyzed

TABLE 3 Significant components and their adjusted loadings.

Directionality	Component	Percent variance explained	Dominant variables	Component loading
−	1. Access to resources	25.525	Percentage of households with a toilet	−0.688
			Percentage of households with a radio	−0.791
			Percentage of households with income from trade	−0.747
			Percentage of households with income from formal employment	−0.903
			Percentage of households with income over M 1000/month (US\$ 83.60)	−0.718
+	2. Vulnerable population groups	11.808	Percentage of child-headed households	0.785
			Percentage of population aged 65 years and above	0.840
			Percentage of orphans	0.776
+	3. Population density	10.741	Total population	0.782
			Number of households	0.619
			Percentage of female population	0.961
+	4. Family structure	9.588	Average population per village	0.550
			Percentage of female-headed households	0.961
			Percentage of population aged 5 years and below	0.961
+	5. Economic status	7.346	Percentage of households receiving social support	0.659
			Percentage of people dependent on home-based care (e.g. HIV/AIDS and tuberculosis patients)	0.708
			Percentage of households with a mobile phone	0.696
			Percentage of households with no income	0.516
+	6. Employment	6.179	Percentage of population with primary education	0.804
			Percentage of households with farm income	0.692
+	7. Access to services	5.308	Population density	0.687
			Percentage of households without access to piped water	0.693
			Percentage of villages without access to roads	0.96
+	8. Rurality	4.452	Average household size	0.550
			Percentage of households with agricultural plots	0.817
Cumulative variance explained		80.948		

variables. The Kaiser criterion was then used as an extraction method (eigenvalues greater than 1) and a Varimax rotation. The Varimax rotation minimizes the number of variables that load high on a single component, increasing the percentage of variation between each. Only components with eigenvalues greater than 1.0 were extracted and named to indicate the latent variable. The component scores were then summed with equal weights to create a final SoVI score. SoVI scores were standardized, then ranked in such a way that positive values indicated high vulnerability scores while negative values indicated lower ones. In the absence of any theoretical justification for the weighting of components, the equal weighting and additive approach seemed to be the most practical (Cutter et al 2003; Schmidtlein et al 2008). For more information on the SoVI, see Hazards and Vulnerability Research Institute (2013). The SoVI scores for each community council were then mapped in ArcGIS as standard deviations (SD) to represent variations in relative social vulnerability levels. The SoVI scores were grouped into 5 categories from most vulnerable to least vulnerable, ranging from $SD > 1.5$ to $SD \leq 1.5$.

Results

The 8 components extracted from the principal components analysis, their rank in importance, the explained variance, and their directionality (\pm) are presented in Table 3. The components include: access to resources, vulnerable population groups, population density, family structure, economic status, employment, access to services, and rurality. The individually adjusted variables and their directionality were made to reflect their known influences on social vulnerability as derived from the empirical literature (Twigg 2001; Cutter et al 2003; Blaikie et al 2005; Wood et al 2010; Yoon 2012; Armas and Gavris 2013; Cutter and Morath 2013). Thus, a positive directionality was allocated to components that likely increase social vulnerability (eg orphans, females, elderly), and a negative directionality was assigned to components that likely decrease vulnerability (eg income, employment, education, wealth).

Table 4 presents SoVI scores for the community councils in the study area from most vulnerable to least vulnerable. The 2 rural and highland community councils in the western part of the study area exhibit the highest levels of social vulnerability, while Mashaleng, an urban community council also in the western part, exhibits the lowest SoVI score (Figure 3). Additionally, urban and lowland community councils such as those of Khoelenya and Liphakoe exhibit relatively low SoVI scores. Community councils showing moderate social vulnerability are found in the central part of the study area.

The SoVI scores were mapped in ArcMap using an SD classification to show spatial differences in levels of social

TABLE 4 Community councils in order of their social vulnerability index scores. Higher scores indicate greater vulnerability.

Community council	Social vulnerability index score
Matsatseng	1.00
Thabana Mokhele	0.84
Mphaki	0.67
Likhutloaneng	0.61
Nkau	0.60
Likhohlong	0.48
Seforong	0.48
Seroto	0.45
Tsatsane	0.39
Qobong	0.39
Siloe	0.34
Motlejoeng	0.33
Mkhono	0.31
Mokotjomela	0.31
Qabane	0.29
Phamong	0.28
Ha Nkoebe	0.24
Qomoqomong	0.23
Khoelenya	0.19
Qhobeng	0.14
Liphakoe	0.13
Teke	0.09
Mootsinyane	0.04
Mashaleng	-0.07

vulnerability across the study area (Figure 3). Three potential clusters of social vulnerability emerged. The most vulnerable community councils were mostly clustered in Mohale's Hoek district, in the western and central parts. The least vulnerable community councils were also predominantly in Mohale's Hoek district and clustered in the western and central parts of the study area. Moderate levels were largely in the central part of the study area. In contrast, Quthing district exhibited clusters of moderate and low vulnerability levels.

Spatial patterns of high social vulnerability occurred in Matsatseng and Thabana Mokhele community councils. Other areas of high vulnerability were also rural, extending to the highlands in both districts (Likhutloaneng, Nkau, and Mphaki). Areas of low social vulnerability exist in Mashaleng. Areas with moderately low vulnerability levels

exist in both districts, mostly in the urban lowlands and foothills (Mootsinyane, Ha Nkoebe, Liphakoe, and Khoelenya). There is a strong cluster of community councils with moderate levels of social vulnerability in the central part of the study area (Mkhono, Mokotjomela, Phamong, Qobong, Seforong, Seroto, and Tsatsane). The remaining highland and some foothill communities of Seforong, Qabane, Likhohlong, Qhobeng, and Nkau have medium levels of social vulnerability. Inaccessibility, lack of access to services and resources, dependency on climate-sensitive agriculture, and mountainous terrain worsen social vulnerability in the remote highland communities. The least vulnerable community councils of Mashaleng and Mootsinyane are urban and periurban areas with a relatively developed infrastructure, access to services, and diverse livelihood options; the majority of their population are literate and engaged in formal employment and have relatively small families.

Factors influencing social vulnerability in Lesotho

A number of spatial patterns emerged for many components; these patterns influenced the overall pattern

of social vulnerability in the study area and indicated where pockets of high social vulnerability are located. Therefore, it is essential to highlight the individual components that contribute to the overall SoVI score shown in Figure 3. By assessing the individual components, the main causes of social vulnerability in each community council can be clearly understood. These scores are discussed in the following 2 sections and mapped in Figures 4 and 5.

Social vulnerability index components 1–4

Access to resources: Factors affecting access to resources include employment and income and are constructed from economic activities engaged by households. The rural community councils of Likhohlong, Likhutloaneng, Mkhono, Qabane, Seforong, and Tsatsane have limited access to resources. Household interviews and field observations confirmed that there were limited formal employment opportunities in areas with limited access to resources, and hence high levels of poverty and social vulnerability. The urban community councils of Liphakoe and Motlejoeng exhibited low SoVI scores in this component.

FIGURE 3 Overall social vulnerability index scores (Map by Moipone Letsie).

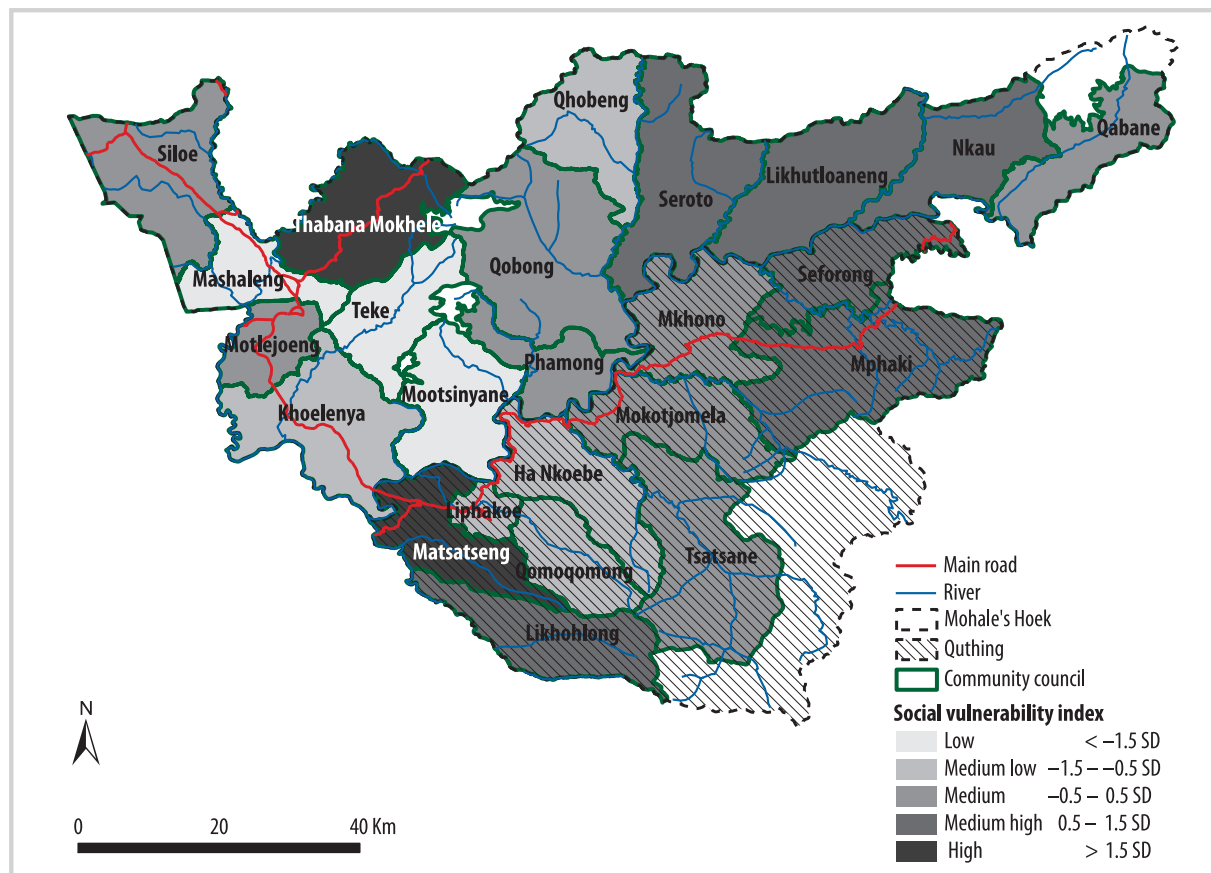
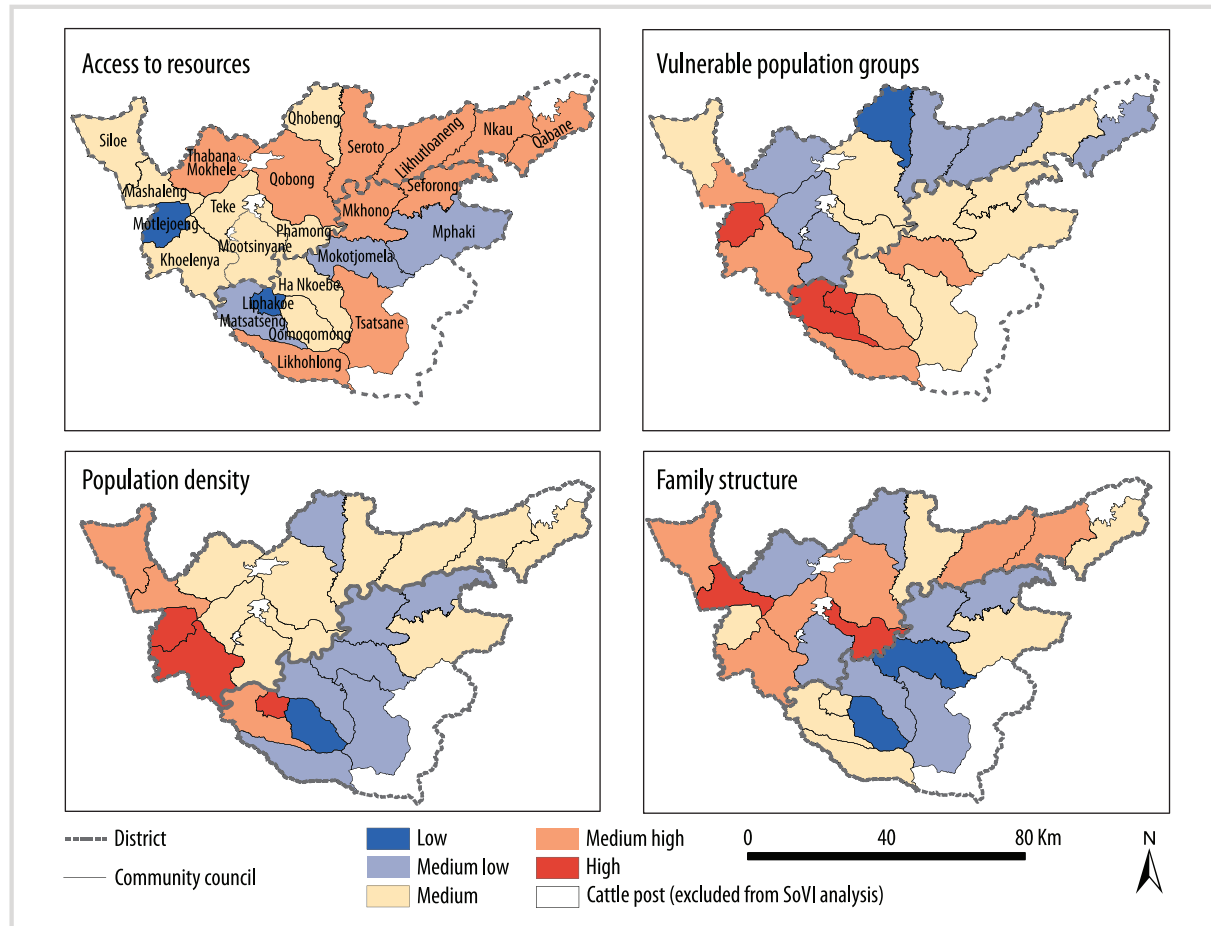


FIGURE 4 Scores for social vulnerability index components 1–4 (Maps by Moipone Letsie).



Vulnerable population groups: Vulnerable population groups include child-headed households, orphans, and people aged 65 years or older. These groups have high prevalence in the urban and peri-urban lowlands. Many orphans and child-headed households were observed on their own in the urban lowlands during field visits, mainly owing to the existence of social networks and cohesion still existing in rural areas of Lesotho, where most orphans are taken care of by relatives and neighbors. Low vulnerability scores for this component were common in the rural highlands.

Population density: The population density component includes total population, number of households, and percentage of female population. High vulnerability scores are evident in the western part of the study area, which consists mainly of the urban and peri-urban lowlands. The southeastern region, particularly Quthing district, had low vulnerability scores in this component. The spatial disparities presented in the population density map emanate from the rural-urban dichotomy, whereby low-lying urban areas are most favorable for

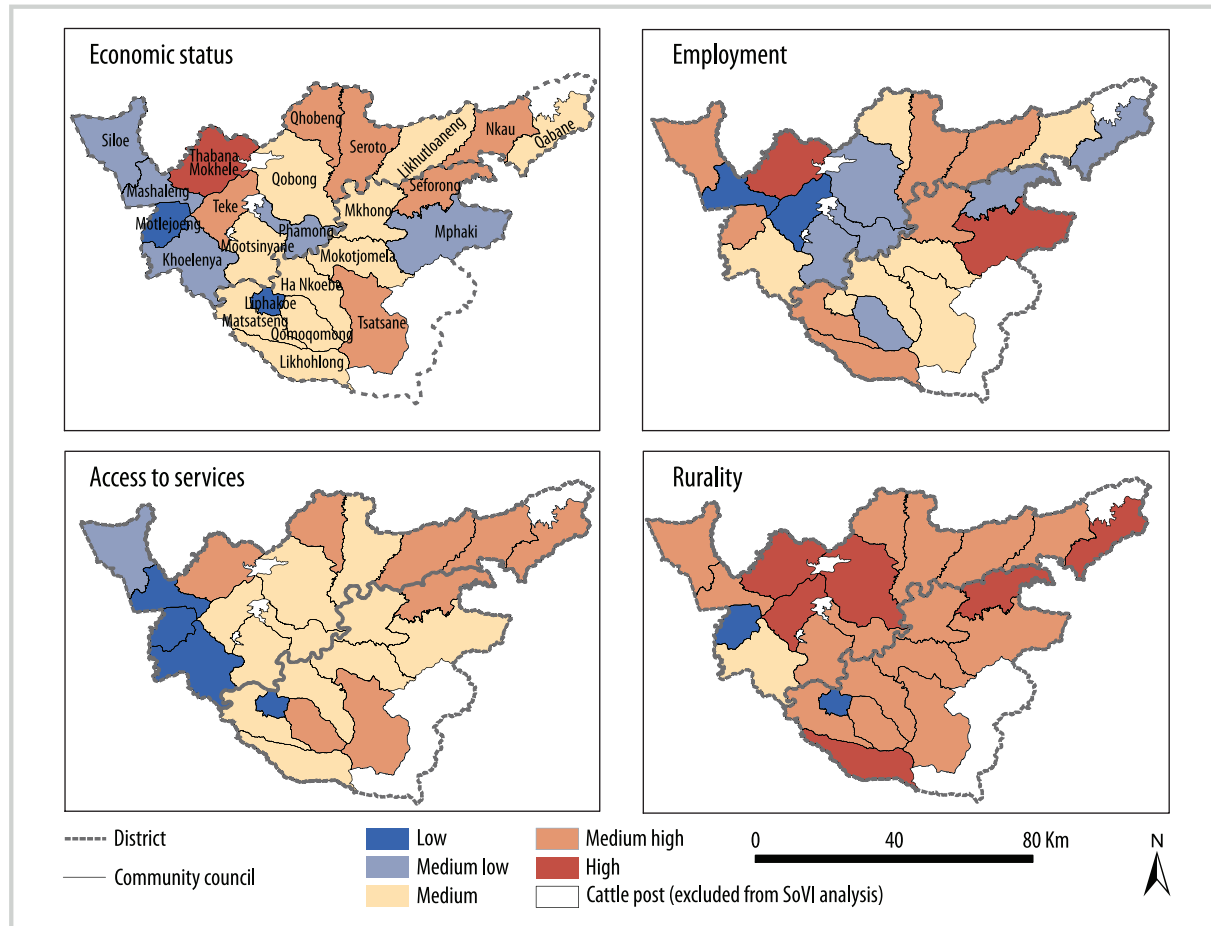
settlements given the availability of arable land, economic opportunities, and social services. Considerably lower population densities are found in remote mountain areas.

Family structure: The family structure component includes the percentage of the population aged 5 years or younger, female-headed households, and population per village. This component did not show a pattern of rural and urban disparities. However, the majority of community councils in the Mphahle's Hoek district scored high in this component.

Social vulnerability index components 5–8

Economic status: The economic status component includes the percentage of households receiving aid, those dependent on social support (e.g., HIV/AIDS and tuberculosis patients), those without income, as well as households owning a mobile phone. Community councils with low SoVI scores for this component are generally those with a majority of households earning regular income and fewer people dependent on social support

FIGURE 5 Scores for social vulnerability index components 5–8 (Maps by Moipone Letsie).



(Khoelenya, Liphakoe, Motlejoeng, and Phamong). In more vulnerable community councils (Nkau, Seforong, Thabana Mokhele, and Tsatsane), the majority of households are dependent on social support and do not earn a regular income.

Employment: The employment component includes the percentage of the population with a primary education and households dependent on farming. Medium to high vulnerability is most evident in community councils hosting many villages in less accessible highland regions (e.g., Likhohlong, Mphaki, and Thabana Mokhele). The least vulnerable community councils are those with a high concentration of villages in close proximity to good road (ie transport) infrastructure and urban centers (eg, Mashaleng and Teke).

Access to services: The component focused on access to basic services and includes total population, access to piped water, and roads. High levels of vulnerability in this component are mainly in rural highlands, while the larger urban settlements (Liphakoe, Mashaleng, and Motlejoeng) have low vulnerability levels. Community

councils with the lowest infrastructure development include those in the remote and inaccessible rural highlands (Qomoqomong, Seforong, Thabana Mokhele, and Tsatsane).

Rurality: The rurality component consists of household size and percentage of households dependent on agriculture. The community councils that are considered highly vulnerable are Mphaki, Qobong, Seforong, Teke, and Thabana Mokhele, all of which are concentrated in rural areas, with the remaining rural community councils having medium–high vulnerability levels. High social vulnerability in the rural areas and foothills results from many of the inhabitants being dependent on subsistence farming and having large families. The least vulnerable community councils, Liphakoe and Motlejoeng, are urban and have diverse livelihood options; the majority of their populations are engaged in formal employment and have relatively small families.

Discussion and conclusions

The adoption of the SoVI approach in Lesotho is of value for several reasons:

- It utilizes secondary sources that are usually available even in data-scarce contexts, an advantage that could also benefit research in other rural mountain regions.
- Its results are consistent with international theoretical understandings and expert opinion on social vulnerability (Dunno 2011; Holand et al 2011).
- Its use of census data means that it can be updated as new data become available, allowing for time-series analyses of social vulnerability (Simpson and Katirai 2006).
- Finally, it offers a way to include local views in quantitative analyses (through household interviews, expert interviews, and focus group discussions) and thus to comply with the framework of the Intergovernmental Panel on Climate Change (IPCC 2012), which calls for the integration of local knowledge with scientific and technical knowledge to improve disaster risk reduction.

This research expands upon Cutter's (1996) Hazards of Place vulnerability model by incorporating qualitative and quantitative data to assess vulnerability. Its theoretical and practical contribution to the literature on natural hazards and vulnerability is that it advances both theory and knowledge about vulnerability within the context of a developing mountainous region in which the lack of accurate and reliable data is often a major limitation. Flexibility in

the selection of data and input variables is required to fully capture the geography of Lesotho and the study region in particular. This study provides a spatially based method for identifying vulnerable populations and communities, which is particularly relevant to dynamic mountainous terrain settings, and compares their levels of vulnerability at district and community council levels. The results can help decision makers to produce more localized and hazard-specific mitigation strategies.

The vulnerability of rural highland communities—due in part to poverty, limited access to resources and services, family structure, and dependence on rain-fed agriculture—is an example of place-based vulnerability. Limited access to resources in these areas is often coupled with low education levels and lack of sanitation facilities and communication tools such as radios and mobile phones. Less socially vulnerable urban community councils have greater ability to cope with natural hazards. Access to economic resources and services, which is strongly influenced by components within given spatial realms in the mountainous regions of Lesotho, is an important factor determining the spatial dynamics of social vulnerability, as is also likely the case in other developing rural mountain regions.

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