Potential for Sustainable Mountain Farming: Challenges and Prospects for Sustainable Smallholder Farming in the Maloti–Drakensberg Mountains

Authors: Adelabu, Dolapo Bola, Clark, Vincent Ralph, and Bredenhand, Emile

Source: Mountain Research and Development, 40(1)

Published By: International Mountain Society

URL: https://doi.org/10.1659/MRD-JOURNAL-D-19-00058.1

Mountain Research and Development (MRD)
An international, peer-reviewed open access journal
published by the International Mountain Society (IMS)
www.mrd-journal.org

MountainAgenda
Target knowledge

Potential for Sustainable Mountain Farming: Challenges and Prospects for Sustainable Smallholder Farming in the Maloti–Drakensberg Mountains

Dolapo Bola Adelabu[1*], Vincent Ralph Clark[2], and Emile Bredenhand[3]
** Corresponding author: solakinns@yahoo.com*
[1] Centre for Sustainable Agriculture, Rural Development and Extension, Faculty of Natural and Agricultural Sciences, University of the Free State, PO Box 339, Bloemfontein 9300, South Africa
[2] Department of Geography/Afromontane Research Unit, Faculty of Natural and Agricultural Sciences, University of the Free State, PO Box 339, Phuthaditjhaba 9866, South Africa
[3] Department of Zoology and Entomology/Afromontane Research Unit, Faculty of Natural and Agricultural Sciences, University of the Free State, PO Box 339, Phuthaditjhaba 9866, South Africa

Achieving sustainable food security is a critical goal for smallholder farmers in mountainous regions around the world. In the 40,000 km^2 Maloti–Drakensberg mountains (South Africa and Lesotho), one of the important mountain ranges of southern Africa, farmers are directly dependent on natural resources. Natural resource management is currently unsustainable, driving landscape degradation and entrenching poverty cycles. Through a comprehensive literature review, we explore the current status of knowledge, opportunities, and agriculture-dependent natural resource sustainability in the Maloti–Drakensberg, and outline the priorities for future research in mountain agriculture in southern Africa. The Maloti–Drakensberg has diverse land tenure systems and climatic heterogeneity that together determine farming practices. Agropastoralism is the predominant agricultural practice, occupying 79% of the land, because of the natural grass-dominated vegetation. Despite decades of concern, the sustainable management of communal rangeland remains elusive. Arable cropping is practiced on 12% of the land at subsistence levels, while game farming contributes a small amount to local revenues. A multipronged research approach is needed to understand the complex social–ecological issues around soil degradation and sustainable utilization of the limited agricultural natural resources base. Innovative and adaptive strategies that take into account local and indigenous knowledge, mitigate soil degradation, and enhance water and rangeland conservation are needed to promote sustainable food production in the Maloti–Drakensberg.

Keywords: *agropastoralism; food security; land use; livestock; mountain farming; southern Africa.*

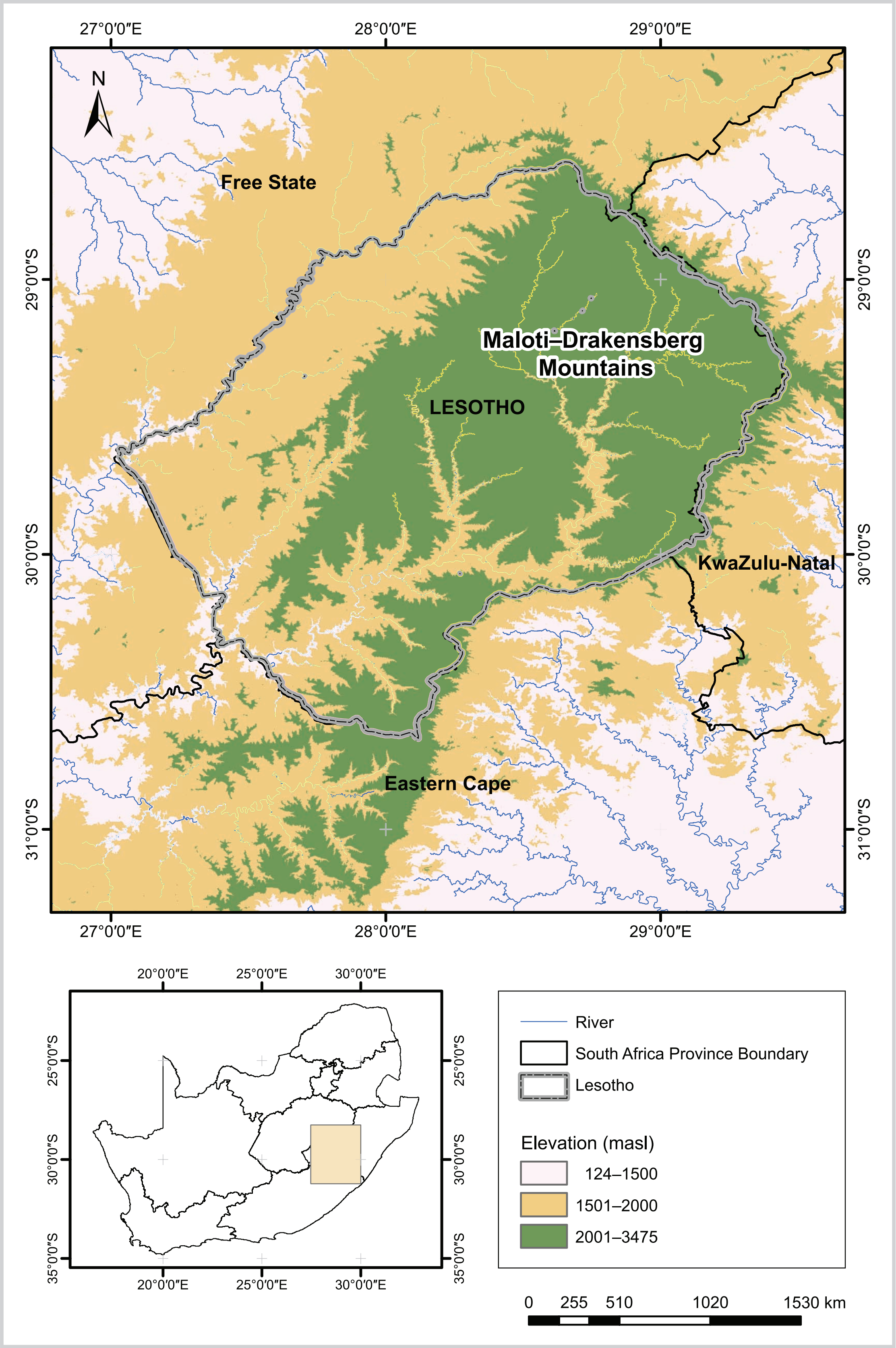
Peer-reviewed: *December 2019* ***Accepted:*** *March 2020*

Introduction

Shifts in population dynamics, population growth, and climate change are predicted to put greater constraints on global food production before the year 2050 (FAO et al 2013; Kohler et al 2014). Higher food productivity requires greater diversification of rural farming systems, especially on marginalized lands, such as those in mountainous areas (FAO 2015a; Sibhatu and Qaim 2017). Land use policies, agricultural practice, and climate change affect the endemic biota. Utilizing biotic interactions to provide desired services in mountain ecosystems could enhance ecologically sound agriculture and influence the livelihoods of mountain dwellers (Körner and Ohsawa 2005; Shennan 2008).

The mountainous environments of eastern and western Africa are densely populated because of their favorable natural conditions for agriculture. Here, cropping systems are more dominant than livestock ranching (Wymann von Dach et al 2013; East African Community et al 2016). In contrast, agropastoralism is the dominant land use in the southern African mountains, which are naturally high-elevation regions with extensive rugged topography (Sen et al 2002; Cloete et al 2010). The Maloti–Drakensberg is the highest mountain range in southern Africa and is shared by Lesotho and South Africa (Figure 1). It covers 40,000 km^2, with most of the high-elevation areas lying in Lesotho. Up to 3500 m, the area is dominated by grassland (Brand et al 2019). The Maloti–Drakensberg has diverse agroecological zones according to elevation (Martelize 2008), namely the montane zone (1280–1830 masl), the subalpine zone (1830–2865 masl), and the alpine zone (2865–3500 masl) (Cloete et al 2014; Blewett 2016; Knight et al 2018). The Maloti–Drakensberg's ecosystems are dynamic and highly susceptible to climatic changes. The annual rainfall varies from 640 mm (Senqu basin) to 1800–2000 mm (highlands). The climate is severe in the alpine belt (above 2700 m), with a mean annual temperature of 5.7°C (MDTP 2015; Mukwada and Manatsa 2018). Mohamed and Mukwada (2019) explain that the continuous rise in temperature increases evapotranspiration and thus has an effect on plant

FIGURE 1 Geographical location of the Maloti–Drakensberg mountains. (Map by Gbenga Efosa Adagbasa)



phenology, reducing pasture in the region. The anticipated climatic changes could be mitigated by developing adaptation strategies, such as the adoption of agricultural practices and technologies that increase the resilience of mountain livelihoods.

The Maloti–Drakensberg mountain bioregion is of global importance and a prime catchment mountain range in southern Africa because of its cultural–social value. It is a center of biological endemism and diversity of plant species, and acts as a primary water tower for Lesotho and South Africa (Brand et al 2019). The people of the Maloti–Drakensberg (>2 million) depend partly or completely on the natural resources for their livelihoods. Household food insecurity is high because of low incomes, high unemployment rates, high food expenditure, large household sizes, limited access to land, and vulnerability to economic shocks (Lawes et al 2007; Wittmayer and Büscher 2010; Chakona 2017; Carbutt 2019). Involvement in agricultural activities is on a subsistence level to supplement food purchases (Davids 2006). Chakona (2017) reported the estimated average income of the poor was less than ZAR 524 (US$ 30.90) per person per month in 2012 and the purchase of food accounted for 60–80% of total household expenditure. The population derived benefits from utilizing and selling products obtained from natural resources, mostly by harvesting the bark of trees for use in medicinal products, grass for the production of brooms and grass hats, and pastures for livestock grazing (Zondo 2016). However, the increasing human population and unsustainable rangeland activities in the Maloti–Drakensberg are gradually transforming the natural grassland environment, degrading the landscape, and making livestock farming a less viable option (Blignaut et al 2010; Carbutt 2019).

In order to achieve Sustainable Development Goals (SDGs) 2 and 15, which emphasize zero hunger and the need for sustainable, resilient food production (SDG target 2.4) as well as conservation of mountain ecosystems (SDG targets 15.1 and 15.4) (FAO 2019b), evidence-based institutional interventions are needed to promote sustainable mountain farming, food security, and sustainability in the Maloti–Drakensberg. Chikazunga and Paradza (2012) have shown that support for farming systems—such as government policies, financial aid, and technological innovations—in southern Africa is biased: more attention is given to lowland and nonmountainous agriculture, whereas mountain agriculture is often neglected.

Similarly, numerous studies on mountainous regions in other parts of Africa, especially in eastern Africa, have a strong focus on mountain agriculture (East African Community et al 2016; Yamane et al 2018). However, in southern Africa, this is a neglected topic, especially with regards to subsistence farming (Wymann von Dach et al 2013). The Maloti–Drakensberg farming systems include both privately owned commercial farming systems with technological resources and subsistence farming systems that largely depend on crude tools and family labor for production.

Balancing food security in the context of accelerating soil degradation, competing land uses, and climate change is the major challenge facing the Maloti–Drakensberg. The establishment of frameworks, methods, and processes that support viable sustainable agriculture is imperative to balance these conflicts (Khwidzhili and Worth 2016). The objective of this review paper is therefore to appraise the status of mountain farming in the Maloti–Drakensberg in terms of its challenges and opportunities for sustainable food production. The key focuses are as follows:

- The current status of the Maloti–Drakensberg smallholding agricultural system in terms of livestock and crop production;
- The potential gaps and priorities for future research in mountain agriculture in southern Africa.

Although this study focuses on the Maloti–Drakensberg, we believe that our findings are applicable to other mountain regions in southern African countries, since they have similar agroecological climates, natural resources, agrobiodiversity, and cultural values (Mabhaudhi et al 2017b).

Methods

The study is mainly based on a literature review. Publications containing quantitative and qualitative research findings were extracted using the following online databases: ISI Web of Science, Google®, Google Scholar®, Scopus, ScienceDirect, and SpringerLink. Considered publications comprised peer-reviewed papers as well as literature published by research institutions and government projects, such as the South African government gazettes, formal reports, working papers, and conference proceedings pertinent to mountain farming. The publication dates ranged from 1941 to September 2019. Based on the objectives of the study, the following search terms were used: “mountain agriculture,” “agriculture in the alpine,” “hill cropping,” “terrace farming,” “family farming,” “marginalized farming,” and “underutilized farming.”

The title, abstract, and full text of articles selected (1547) were manually screened for relevance based on criteria defined by the objectives of the review. Our first choice was scientific articles dealing with the criteria within southern Africa. However, this yielded relatively little information on subsistence farming in mountains (<40 peer-reviewed articles were found). Hence, literature on other mountain regions in Asia and Europe with similar environmental conditions—such as similar elevational range, climatic conditions, and socioeconomic patterns—were also considered. Overall, 105 publications were critically reviewed, one by one, and relevant insights were categorized to build arguments for the following 2 groups: Maloti–Drakensberg current land use, based on local studies; and potential strategies to improve Maloti–Drakensberg agriculture, which were deduced from additional options developed in mountain farming in other countries with similar environmental conditions.

Results and discussion

Current land use in the Maloti–Drakensberg

The Maloti–Drakensberg comprises a mosaic of land tenure that includes private and state land (Knight et al 2018). State land includes communal land tenure, protected areas, and state forestry, among others. However, communal land tenure is under the control of traditional authorities, such as the amaNgwane and amaZizi traditional councils. Land in the Maloti–Drakensberg includes cultivation land (12%), rangeland (79%), and land for "other development" (8%) (MDTP 2008, 2015; Shezi 2019). The communal land hosts subsistence agriculture, while commercial farming dominates the private land (Zunckel 2012). Subsistence farming relies predominantly on family labor and plays a major role in food security and poverty eradication (MDTP 2015; Rodrigues et al 2017). Blair et al (2018) indicated that land use in mountainous environments is based on cultural practices, behaviors, and the needs of the local communities. Farming in the Maloti–Drakensberg supports extensive livestock production (Cloete et al 2010), subsistence cropping, fishing, and game farming (Turpie et al 2007). Cropping practices are characterized by the production of cereal, cucurbits, pulses, oilseeds, fodder crops, vegetables, and natural growth of medicinal plants (MDTP 2015). Most of these supplement food that is purchased for household food consumption (Davids 2006).

Rangeland grazing and livestock management: Owing to the rugged landscape, soil with high clay fractions, limiting macronutrients (nitrogen and phosphorus), low temperatures, increasing nutrient leaching, and mesic grassland cover in the Maloti–Drakensberg, the dominant land use is livestock farming, which contributes immensely to the socioeconomic growth of rural dwellers (Zunckel 2003; Carbutt and Edwards 2015). Almost 55% of smallholder farmers practice livestock farming with cattle, goats, and sheep, while approximately 25% of the farmers engage in cropping, and the remaining 20% are involved in other activities, such as hunting, cultivation of medicinal plants, and fishing (Elleboudt 2012; BFAP 2018). Beef cattle and dairy production are important to their livelihoods, whereas meat production from monogastric animals is less favored in the region (Elleboudt 2012). In southern Africa, communal livestock serve various purposes other than food; for example, draft power for plows and wagons, cultural value (such as marriage payments and in rituals), and a more stable investment than volatile national currencies (Ndoro and Hitayezu 2014).

Rangeland productivity depends on the grazing management of biotic (browsers, large and small stock) and abiotic (climate and lithology) components of the Drakensberg farming system (Hawkins 2017). Rangeland management in southern Africa comprises rotational grazing, zero grazing, or a combination of both, monitoring stocking rate, camp size, and recovery periods. However, no specific information on current grazing management is available in the unprotected areas of the Maloti–Drakensberg, which have been extremely stressed. Decades of overgrazing, especially in communal contexts, without effective rangeland governance have reduced the carrying capacity dramatically and is associated with widespread land degradation in the form of bush encroachment, soil erosion, and wetland loss (Brand et al 2019). Some areas of the Maloti–Drakensberg, such as around Mokhotlong in Lesotho, are now facing ecosystem collapse, with consequent negative impacts on water security, agrarian livelihoods, and social cohesion (Dunnink et al 2016; Brand et al 2019). Rangeland under commercial land use on private farms is generally in much better condition, contributing highly to water production and biodiversity conservation as de facto conservation areas (Zunckel 2003). The largest areas of private rangeland in the Maloti–Drakensberg are in the Eastern Cape areas, centered on the towns of Rhodes and Barkley East (Carbutt et al 2011).

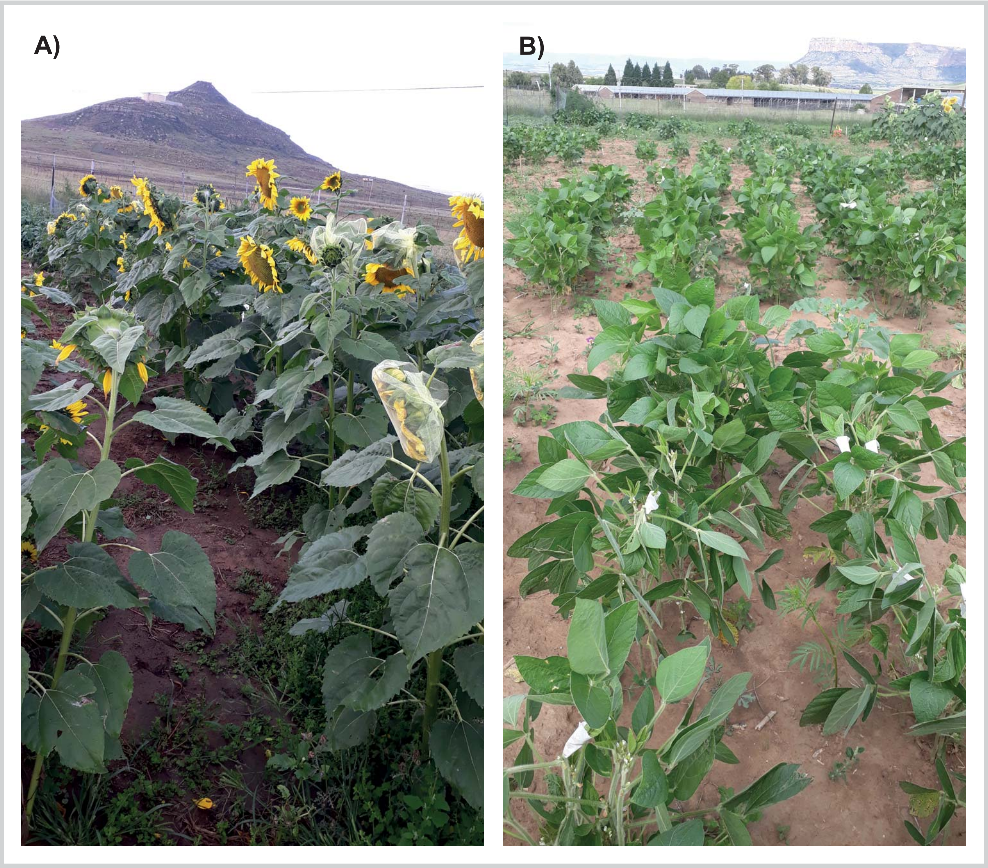
Cropping system in the Maloti–Drakensberg: In comparison to other southern African mountain areas, the Maloti–Drakensberg experiences relatively high summer rainfall (>700 mm) and has fertile soils. This enables summer cropping of cereals, cucurbits, root and tuber crops (potatoes), legumes, oil crops (sunflower and soybeans), and fodder crops on the lower slopes and in the foothills (Zunckel 2003; Taylor et al 2016; Mukwada and Manatsa 2018). Maize is the main summer cereal crop, while winter sorghum, oats, and wheat are grown mainly as fodder crops in winter (Turpie et al 2007). The broad acceptability of maize is due to the wide adaptability of the crop to varying environmental conditions (Arnalte 2009; Akinnuoye-Adelabu et al 2017). Currently, crop farming in the Maloti–Drakensberg takes the form of subsistence farming with relatively little government support (Zunckel 2003) (Figure 2). Intercropping and crop rotation are 2 of Maloti–Drakensberg farmers' many livelihood strategies to cope with the fragile mountain ecosystems, safeguard food supply, and meet the dietary requirements of households (Carbutt and Edwards 2015; De Wit et al 2015) in low-temperature and soil macronutrient–limited agroenvironments (Mukwada and Manatsa 2018).

Game farming: Small-scale farmers in the Maloti–Drakensberg experience various sources of uncertainty in their farming practices. These are caused by complex, dynamic, and interrelated factors, such as livestock theft, climate change, the withdrawal of subsidies, changes in labor relations, and instability in produce prices through global economic competition (Salomon 2011; Ndoro et al 2014). Uncertainty in the profitability of conventional livestock farming has made some farmers switch to game farming; the rationale is that indigenous wildlife is better adapted to the local climatic conditions than livestock and is therefore easier to farm (Mahlobo 2016). Game farming is the management of indigenous wildlife (usually larger mammals, such as antelope) in a sizable fenced system, with human intervention through provision of water, supplementation of food in periods of drought, the control of parasites, and the provision of health care (Porter 2016).

Although game farming is usually the domain of wealthier private landowners, some communities under tribal authority are also considering this as an alternative to communal livestock (MDTP 2015). For both private and communal game farming, the benefits of wildlife-based enterprises cascade into leisure and ecotourism, trophy hunting, game auctions, and other activities with a high financial return, creating 3 times more employment opportunities than livestock (Rassool and Witz 1996; Shroyer and Blignaut 2003; Brooks et al 2011; Sert 2017). In South Africa, under favorable government policy and regulations, game farming accounts for 25% of the national gross domestic product (de Beer 2009).

Currently, there are approximately 180 game farms in eastern Free State, with an average farm size of 821 ha (Du Toit et al 2013), which focus on game capturing, selling, and hunting (Shroyer and Blignaut 2003). Typical species farmed are eland (*Taurotragus oryx*), blesbuck (*Damaliscus pygargus phillipsi*), springbuck (*Antidorcas marsupialis*), grey rhebok

FIGURE 2 Example of crops that thrive well in the Maloti–Drakensberg. (A) Sunflower; (B) soybean plants at their reproductive stage. (Photos by Dolapo Bola Adelabu)

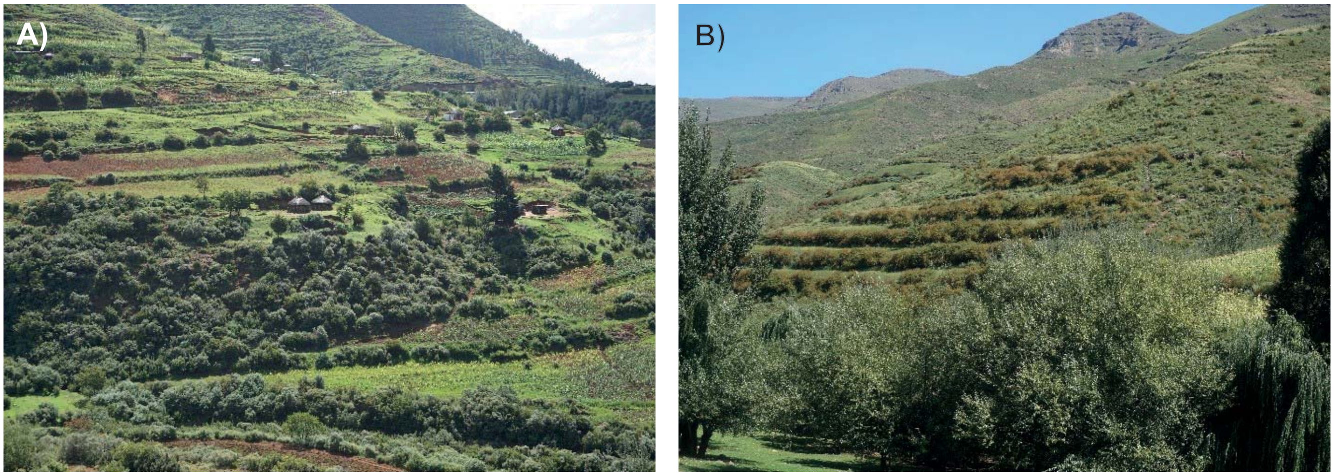


(*Pelea capreolus*), mountain reedbuck (*Redunca fulvorufula*), Burchell's zebra (*Equus quagga burchellii*), bushbuck (*Tragelaphus sylvaticus*), black (*Connochaetes gnou*) and blue wildebeest (*Connochaetes taurinus*), and red hartebeest (*Alcelaphus buselaphus caama*). Most of the Maloti–Drakensberg area is unsuitable for the reintroduction of larger mammals, such as elephant (*Loxodonta* spp), rhino (*Rhinoceros* spp), giraffe (*Giraffa* spp), and hippo (*Hippopotamus* spp), or for predators, such as lion (*Panthera leo*), though leopard (*Panthera pardus*) still occurs naturally in the Maloti–Drakensberg. Major challenges of game farming include limiting the natural movement of wildlife (the Maloti–Drakensberg historically has had major seasonal migrations between higher and lower elevations) and the introduction of genetic strains not indigenous to the Maloti–Drakensberg. These lead to the danger of stressing the animals through inadequate forage in winter months, overgrazing, and loss of local genetic identity among the remaining indigenous populations (Bond et al 2004).

Harnessing medicinal plants: With some 2800 plant species, the Maloti–Drakensberg supports many species of medicinal plant (Moffett 2016). Medicinal plants, such as cancer bush (*Sutherlandia frutescens*), bitter aloe (*Aloe ferox* Mill.), rabassamin (*Pelargonium sidoides*), pineapple flower (*Eucomis autumnalis*), and Africa potato (*Hypoxis hemerocallidea*), grow naturally in the Drakensberg in KwaZulu-Natal and the eastern Free State (Mander 1998; Street and Prinsloo 2013). Everlasting herb (*Helichrysum odoratissimum*), wild garlic (*Tulbaghia violacea*), and wild wormwood (*Artemisia afra*) are found in the region. An ever-growing demand for such plants from southern Africans is resulting in unsustainable harvesting (Street and Prinsloo 2013; Van Wyk and Prinsloo 2018). Thus, conservation and sustainable utilization of these natural resources are imperative for the benefit of current and future generations. Replanting of the harvested seeds or cuttings and cultivation of medicinal plants in the mountain terrains could enhance the sustainability of medicinal plants in the Maloti–Drakensberg (Jewitt et al 2015; DAFF 2016).

Fish farming: Fish farming is among the world's fastest-growing sustainable food production industries (Godfray et al 2010). The Maloti–Drakensberg is one of the most water-abundant parts of southern Africa, with cool temperate waters in the form of natural rivers and streams, tarns, lakes, and artificial reservoirs of all sizes (from small farm impoundments to the Lesotho Highlands Water Scheme Dams, such as Katse and Mohale dams). Cool seasonal water temperatures (4–13°C) and high mean annual precipitation (up to 2000 mm) are considered to be of primary importance in fish farming (Skelton 2000; Nel et al 2010). In the Maloti–Drakensberg, smallmouth yellowfish (*Labeobarbus aeneus*) and rainbow trout (*Oncorhynchus mykiss*) are among the main fish produced in hatcheries (Ellender and Weyl 2014). Although the freshwater fishing industry in South Africa is a high-risk economic sector, because of limited seasonal availability of freshwater sources, the government policy on licenses was set in place to help regulate the conservation of endemic and endangered fish species (notably the Maloti minnow, *Pseudobarbus quathlambae*), and restrict farming around

FIGURE 3 Evidence of terrace farming along the Maloti–Drakensberg in Lesotho. (Photos by Andreas Muhar)



wetlands to safeguard against water pollution. However, fish farming in South Africa is believed to have good future prospects because of its stable prices, growth in local market demand, and its relationship with steadily growing tourism (Stander 2009). This is promising for initiatives in the best farm locations, such as in the Maloti–Drakensberg, provided that good operational management prevails (FAO 2016).

Potential strategies to improve smallholder farming systems in the Maloti–Drakensberg

Management of communal rangeland, pasture, and cultivation lands in the Maloti–Drakensberg is complex because it is linked to local leadership and governance issues. It requires the cooperation of subsistence farmers on the communal land, traditional leaders, and communities (MDTP 2015).

Rejuvenating old terraced lands: There is scant information on terrace farming in the Maloti–Drakensberg and other southern African mountain areas. However, there is evidence of previous terrace farming in the Maloti–Drakensberg (Figure 3). The Machobane farming system adopted in the mountainous regions of Lesotho gives the cropping system high adaptability and resilience to climate change (Mekbib et al 2017). Most resource-poor farmers have no access to a scientific knowledge system; instead, they rely on their local and indigenous knowledge to sustain food production. Terrace farming is an indigenous practice, and is one of the most successful techniques for water and soil conservation on steep slopes in other mountainous areas in China, Peru, and southern Ethiopia (Denison and Wotshela 2009; Engdawork and Bork 2014; Chapagain and Raizada 2017). Gertenbach (1941) reported old practices of terrace farming, such as stacking stones parallel to hillside contours, for cropping purposes in the Drakensberg region of KwaZulu-Natal. Campbell et al (2014) indicated that stone terraces, when combined with other land management techniques, double the yield increase of sorghum and millet in the drylands of western Africa. Rejuvenating traditional terrace stone walls in the Maloti–Drakensberg could therefore help mitigate soil degradation (gully and sheet erosion) and promote soil water conservation techniques. A report by the World Overview of Conservation Approaches and Technologies (WOCAT 2007) indicated that soil erosion and degradation in other mountainous areas of the world have been mitigated through this practice.

Likewise, control measures, such as revegetation using vetiver grass (*Chrysopogon zizanioides*) and strict conservation tillage on semiarid mountainous farmland, help to mitigate erosion, as in other mountainous areas of South Africa and Asia (WOCAT 2007; Hilger et al 2013). However, the potential of terrace farming to increase food productivity needs to be carefully examined in the Maloti–Drakensberg (Hendriks et al 2016).

Reducing soil degradation: The Maloti–Drakensberg's ecosystems are dynamic and highly susceptible to climatic changes, accelerated soil erosion, and landslides, leading to rapid loss of habitats and genetic diversity, soil degradation, and reduction in soil water availability (Mukwada and Manatsa 2018). Extensive tillage-based cultivation and overgrazing have aggravated the problem (Meadows and Hoffman 2002). Free State province has a large area (>2 million ha) exposed to erosion, of which the Maloti–Drakensberg occupies a significant percentage (Le Roux and Smith 2014). The impoverishment of the soil causes greater vulnerability to droughts, increases difficulties in agricultural production, and modifies land- and water-based ecosystems. Attempts to deal with soil degradation caused by erosion in Maloti–Drakensberg farming systems need area-specific management strategies that identify and map current erosion-prone areas and introduce measures to prevent the loss of vegetation cover. Farmers in the Maloti–Drakensberg have to harness potential that could be derived from soil conservation measures. Measures include cover crops, returning plant residues to the soil, crops with strong rooting systems that protect and improve soil resources, and rotational grazing management in Maloti–Drakensberg farming systems (Le Roux and Smith 2014). Given the limited scientific information on the processes and extent of soil degradation in the Maloti–Drakensberg, research should be increased to fill the knowledge gap and to identify adequate and place-specific conservation approaches and technologies

TABLE 1 Common challenges associated with Maloti–Drakensberg soils and potential solutions identified in similar contexts.

Common challenges	Causes	Remediation measures	Specific solutions	References
Accelerated gully and sheet erosion and soil loss	Illegal grassland burning and overgrazing	Increase the even distribution of vegetation cover to reduce the severity of wind- and water-induced erosion	Planting of soil cover crops, zero tillage, grazing, crop rotations, creation of terraces and contours to reduce the erosion	de Winnaar et al (2007); Carbutt and Edwards (2015); Nüsser and Grab (2002)
Highly leached acidic sandy soils	Presence of basaltic and sandstone soil formation, high volume of precipitation delivered during intense thunderstorms	Maintain the vegetation to bind and improve the soil structure	Soil amendment practices, such as vermicompost and biochar application, planting of deep-rooted crops, planting of underutilized and water-efficient crops, adjustment of plant population, relay planting, and seed priming	Carbutt and Edwards (2015); Peden (2004); Schimmelpfennig et al (2014)
Thawing and freezing (formation of needle ice)	High elevation	Cultivate the foothills, protect seedling establishment stage and root development	Soil cover and no-till conservation agriculture, plastic-bag nursery before transplanting in the field, land management techniques such as pit planting and stone bunds	Beniston (2003); Campbell et al (2014); Showers (2006)
Presence of heavy metals such as sesquioxides of Al, Fe, and Mn, many of which are toxic to plants[a)]	Low-pH soil environment	Improve chemical conditions at the subsoil level	Improvement of high clay and soil organic matter fractions characteristic of mountain soils and complexation chelates that bind up Al^{3+} and render it nonexchangeable	Carbutt and Edwards (2015)

[a)]Al, aluminum; Fe, iron; Mn, manganese.

and agronomic solutions to inform policies and regulation legislation.

Improving agronomic management through sustainable farming: The system of crop intensification could advance the productivity and resilience of crops by optimizing the benefits of available resources for improved plant growth and development (Adhikari et al 2018). Practices that return organic materials to the soil have been encouraged in mountainous regions of South America and Asia (Chapagain and Raizada 2017). However, residues applied to the aerated and porous soils of most mountainous regions could decompose rapidly and have no positive effect on the soil quality (FAO 2015b). Since the Maloti–Drakensberg still has moderate soil organic matter content (Mapeshoane 2013), returning organic plant parts to the soil could help protect against erosion and conserve soil biota. Soil conservation strategies include cultivation of deep-rooting plants on slopes up to 45% (Harden 2013). Further, soil amendment strategies such as vermiculture, improved trash lines, and addition of biochar should be encouraged in the Maloti–Drakensberg (Gobozi 2018). Agronomic practices, such as adjusting plant densities, relay planting, crop rotation, cover-crop management, and application of balanced organic and inorganic fertilizers (Table 1), would boost soil biota populations, increase diversity, and improve sustainable cropping in the Maloti–Drakensberg (Carbutt and Edwards 2015).

Embracing underutilized crops in the Maloti–Drakensberg: The Maloti–Drakensberg farming systems focus mainly on staple crop production, with very little cultivation of underutilized or indigenous crops (Zunckel 2003; Mabhaudhi et al 2017b). The few underutilized crops cultivated have fairly informal market arrangements, depending on local culture, tastes, and traditional knowledge (Mabhaudhi et al 2016). The current market value of underutilized crops is unknown (Gulzar and Minnaar 2017). Underutilized crops, such as buckwheat (*Fagopyrum esculentum*) and finger millet (*Eleusine coracana*), are not staples but have the potential to contribute to food security. They could enhance nutrition, health, income generation, and agroecological and environmental services through increased productivity, better marketing, and home consumption (Chivenge et al 2015).

Underutilized crops that could be adapted to Maloti–Drakensberg farming systems are listed in Table 2. They are less dependent on soil nutrients, resilient to climatic change, adaptable to low-input agriculture, and have a rich nutritional profile (Mabhaudhi et al 2017b). They thrive well and are better able to restore degraded and marginal lands than commercially grown crops, making them advantageous for sustainable cultivation (Gulzar and Minnaar 2017; Mabhaudhi et al 2017a, 2017b). Thus, their promotion in marginal agricultural production areas, such as the Maloti–Drakensberg, could improve accessibility to nutritious foods. The crops have a wide genetic pool and provide an important subset of agrobiodiversity and genetic breeding possibilities (Mabhaudhi et al 2019), thus contributing to the

TABLE 2 Prospective crops suitable for cultivation in the Drakensberg.

Ecological zone	Current crops grown	Underutilized crops with prospects for cultivation	References
Southern Drakensberg (subhumid)	Maize (*Zea mays*), beans (*Phaseolus vulgaris*), spinach (*Spinacia oleracea*), sunflower (*Helianthus annuus*), cowpea (*Vigna unguiculata*), Chinese cabbage (*Brassica rapa*), tea (*Camellia sinesis*), coffee (*Coffea* spp), potatoes (*Solanum tuberosum*)	Bottle gourd (*Lagenaria siceraria*), sorghum (*Sorghum bicolor*), finger millet (*Eleusine coracana*), African eggplant vegetable (*Solanum aethiopicum*), cowpea (*Vigna unguiculata*), wild mustard (*Brassica juncea*), jute mallow (*Corchorus olitorus*), *Cucurbita* spp, spider plant (*Cleome gynandra L.*), peas (*Pisum sativum*), carrots (*Daucus carota*), sweet potatoes (*Ipomoea batatas*), and bambara groundnut (*Vigna subterranea*)	Adhikari et al (2017); Mabhaudhi et al (2017b)
Central and Northern Drakensberg (semiarid)	Maize (*Zea mays*), sorghum (*Sorghum bicolor*), spinach (*Spinacia oleracea*), potatoes (*Solanum tuberosum*), cabbage (*Brassica* spp), pasture crops	Pearl millet (*Pennisetum glaucum*), African eggplant (*Solanum macrocarpon*), cowpea (*Vigna unguiculata*), wild mustard (*Brassica juncea*), jute mallow (*Corchorus olitorus*), Chinese cabbage (*Brassica rapa*), various *Cucurbita* spp, bitter watermelon (*Momordica charantia*), spider plant (*Cleome gynandra L.*), sweet potatoes (*Ipomoea batatas*), bambara groundnut (*Vigna subterranea*), devil's thorn (*Tribulus terrestris*), gallant soldier (*Galinsoga parviflora*), yellow justicia (*Justicia flava*), star stalk (*Oxygonum sinuatum*), sticky gooseberry (*Physalis viscose*), purslane (*Portulaca oleracea*), black nightshade (*Solanum nodiflorum*), and giant bell flower (W*ahlenbergia undulata*)	Mabhaudhi et al (2017a, 2017b); Msuya et al (2010)

stability and risk management of farming systems and conservation of agrobiodiversity, as well as strengthening the cultural identity and empowerment of local farmers (Jaenicke and Lengkeek 2008).

Climate-smart agriculture: Climate-smart agriculture is an approach for developing agricultural strategies that identify and secure sustainable food security under climate change conditions (FAO 2019a). It improves farming insurance and risk management through adequate land use planning and climate forecasting. The Machobane system used in Lesotho involves the integration of organic fertilizers, improved local breeds, crop rotation, intercropping, and relay cropping to safeguard against climate change and unpredictability (Mosenene 2002; Klein et al 2007; Cardoza et al 2012). Adeyemi et al (2017) argued that a proper combination of soil, crop, and weather sensors would give advance precision data to support adaptive decision systems improve sustainability in agriculture. Currently, precision technology and data are not used in Maloti–Drakensberg farming. However, climate-smart agriculture practices were introduced to local farmers from Nhlazuka in KwaZulu-Natal through the uMngeni Resilience Project in South Africa in 2018 (SANBI 2019), where farmers were educated on different techniques and interventions that could increase food production while adapting to climate change. Such innovations are strongly required in Maloti–Drakensberg farming systems.

Roles of policymakers and mountain agriculture: Policymakers and researchers have not given adequate attention to small-scale farming in southern African mountain areas, although this is currently attracting interest (De Wit et al 2015; FAO 2015a). Institutions such as the Maloti–Drakensberg Transfrontier Conservation and Development Project (https://www.tbpa.net) focus on enhancing and implementing proper rangeland management, preventing land degradation, and implementing rehabilitation plans for areas currently degraded in the Maloti–Drakensberg. Promotion of different farming systems in the region and research collaboration with universities, with farmer engagement, could raise food production in mountainous environments in southern Africa.

The Afromontane Research Unit of the University of the Free State harnesses interdisciplinary expertise focusing on sustainable development in the Maloti–Drakensberg (Mukwada et al 2016; Le Roux et al 2018). There is increasing need for research toward sustainable food systems in the Drakensberg.

The South African Department of Agriculture, Forestry and Fisheries (DAFF) has an important role to play at the policy level in promoting mountain agriculture (DAFF 2017). Currently, the food security policies guiding research, production, and marketing of agricultural produce from mountainous areas exert little influence over subsistence mountain food production. Specific policies on agricultural expansion, such as granting agricultural subsidies and minimum selling prices with regard to products from marginal land, are essential. Grassroots networking programs should be organized among mountainous subsistence farmers, such as the one-household–one-hectare program at Ficksburg in the eastern Free State of South Africa (OVK Retail Division 2019). This would improve the dissemination of important information that could increase food security in the nation.

Conclusion and recommendations

Agriculture in the Maloti–Drakensberg is dominated by communal tenure systems that require strategic interventions to improve productivity and address soil degradation. Given the complexities of the challenges, the following situations and policy intervention are required:

- Adaptive strategies that focus on soil and water conservation through resilient cropping practices using underutilized crops that require low farming inputs and are indigenous to the landscape. Sustainable grazing management could also help boost food security in the area.
- All forms of local and indigenous knowledge used by the local farmers in the Maloti–Drakensberg should be encouraged and assessed, through agricultural advisory services and technical interventions within the mountain communities.
- Measures that enhance effective rangeland and pastureland governance by monitoring livestock carrying capacity in unprotected areas of the Maloti–Drakensberg should be put in place by the government.
- Training programs on sustainable food production, conservation, and sustainable utilization and benefits of healthy natural ecosystems should be organized by research institutions, thereby educating Maloti–Drakensberg farmers on ways to sustainably farm within the fragile mountain ecosystems.
- Area-specific management strategies that identify and map current erosion-prone areas should be developed and measures to conserve vegetation cover introduced. Broad-scale control strategies to prevent further gully erosion may be expensive and more difficult to attain in severely eroded areas. However, control measures like revegetation, conservative agriculture, and restoration of traditional terrace stone walls would help mitigate the soil degradation.

A transboundary research effort that incorporates social and cultural nuances is needed in the Maloti–Drakensberg. The results of this could be used to develop agronomic solutions and formulate legislation. This will require organizing grassroots networking programs among the stakeholders concerned (nongovernmental organizations, faith-based groups, institutions, agroindustries, and aid organizations). Measures such as smallholding features and smart agriculture and intervention of researchers, agricultural extension personnel, and government agencies that assist the Maloti–Drakensberg farmers in adopting more sustainable farming practices to support the growing population without compromising the natural environment are urgently needed. The smallholding feature of Maloti–Drakensberg has the potential to enhance sustainable agricultural development compared with other mountainous farming systems in developed countries (Körner and Ohsawa 2005; FAO 2001; Rodrigues et al 2017). This review found limited documentation of the current indigenous knowledge that prevails in Maloti–Drakensberg mountain farming. More research focusing on innovative strategies and establishment of regional networks to better understand the vulnerability of mountain communities is essential. Empowering local people to reverse agrarian-based poverty cycles and natural resource degradation will be essential for the long-term sustainable development of the Maloti–Drakensberg.

ACKNOWLEDGMENTS

We wish to express our appreciation to Dr Graham Baker and Elisabeth Lickindorf for their assistance with proofreading and editing of this manuscript; also, to Dr Adagbasa Gbenga Efosa for his help in generating the Maloti–Drakensberg map and Prof. Andreas Muhar for providing photographs of terrace farming in the Maloti–Drakensberg. This work was supported by the University of the Free State.

REFERENCES

Adeyemi O, Grove I, Peets S, Norton T. 2017. Advanced monitoring and management systems for improving sustainability in precision irrigation. *Sustainability* 9:353.
Adhikari L, Hussain A, Rasul G. 2017. Tapping the potential of neglected and underutilized food crops for sustainable nutrition security in the mountains of Pakistan and Nepal. *Sustainability* 9(2):291.
Adhikari P, Araya H, Aruna G, Balamatti A, Banerjee S, Baskaran P, Barah B, Behera D, Berhe T, Boruah P. 2018. System of crop intensification for more productive, resource-conserving, climate-resilient, and sustainable agriculture: Experience with diverse crops in varying agroecologies. *International Journal of Agricultural Sustainability* 16:1–28.
Akinnuoye-Adelabu DB, Modi AT, Mabhaudhi T. 2017. Potential of producing green mealies in summer and winter at two sites in KwaZulu-Natal, South Africa, considering rainfall, soil moisture and weeding. *South African Journal of Plant and Soil* 34:211–221.
Arnalte L. 2009. *Small Farmers in the Highest South-African Mountains*. http://base.d-p-h.info/en/fiches/dph/fiche-dph-7074.html; accessed on 30 January 2020.
Beniston M. 2003. Climatic change in mountain regions: A review of possible impacts. *In:* Diaz HF. *Climate Variability and Change in High Elevation Regions: Past, Present & Future*. Dordrecht, Netherlands: Springer, pp 5–31.
BFAP [Bureau for Food and Agricultural Policy]. 2018. *BFAP Baseline. Agricultural outlook 2018–2027*. Pretoria, South Africa: BFAP Baseline. www.bfap.co.za; accessed on 11 March 2020.
Blair D, Shackleton CM, Mograbi PJ. 2018. Cropland abandonment in South African smallholder communal lands: Land cover change (1950–2010) and farmer perceptions of contributing factors. *Land* 7:121.
Blewett M. 2016. *Drivers of Land Use Change in the Drakensberg Mountains, South Africa* [MSc thesis]. Pretoria, South Africa: University of Pretoria.
Blignaut J, Mander M, Schulze R, Horan M, Dickens C, Pringle C, Mavundla K, Mahlangu I, Wilson A, McKenzie M, et al. 2010. Restoring and managing natural capital towards fostering economic development: Evidence from the Drakensberg, South Africa. *Ecological Economics* 69(6):1313–1323.
Bond I, Child B, de la Harpe D, Jones B, Barnes J, Anderson H. 2004. *Parks in Transition*. London, United Kingdom: Routledge.
Brand RF, Scott-Shaw CR, O'Connor TG. 2019. The alpine flora on inselberg summits in the Maloti–Drakensberg Park, KwaZulu-Natal, South Africa. *Bothalia* 49(1):a2386.
Brooks S, Spierenburg M, Van Brakel L, Kolk A, Lukhozi KB. 2011. Creating a commodified wilderness: Tourism, private game farming, and 'third nature' landscapes in KwaZulu-Natal. *Tijdschrift voor Economische en Sociale Geografie* 102:260–274.
Campbell BM, Thornton P, Zougmoré R, Van Asten P, Lipper L. 2014. Sustainable intensification: What is its role in climate smart agriculture? *Current Opinion in Environmental Sustainability* 8:39–43.
Carbutt C. 2019. The Drakensberg Mountain Centre: A necessary revision of Southern Africa's high-elevation centre of plant endemism. *South African Journal of Botany* 124:508–529.
Carbutt C, Edwards TJ. 2015. Plant–soil interactions in lower–upper montane systems and their implications in a warming world: A case study from the Maloti-Drakensberg Park, Southern Africa. *Biodiversity* 16:262–277.
Carbutt C, Tau M, Stephens A. Escott B. 2011. The conservation status of temperate grasslands in southern Africa. *Grassroots* 11(1):17–23.
Cardoza YJ, Harris GK, Grozinger CM. 2012. Effects of soil quality enhancement on pollinator–plant interactions. *Psyche: Journal of Entomology* 2012;581458.
Chakona G. 2017. *Changes in household food security, nutrition and food waste along an agro-ecological gradient and the rural-urban continuum in mid-sized South African towns* [PhD dissertation]. Grahamstown, South Africa: Rhodes University).
Chapagain T, Raizada MN. 2017. Agronomic challenges and opportunities for smallholder terrace agriculture in developing countries. *Frontiers in Plant Science* 8:331.
Chikazunga D, Paradza G. 2012. *Can Smallholder Farmers Find a Home in South Africa's Food-System? Lessons from Limpopo Province*. Pretoria, South Africa: Institute for Poverty, Land and Agriculture Studies (PLAAS). http://www.plaas.org.za/blog/can-smallholderfarmers-find-home-South-Africa's-food-system-lessons-Limpopo province; accessed 9 November 2012.

Chivenge P, Mabhaudhi T, Modi AT, Mafongoya P. 2015. The potential role of neglected and underutilised crop species as future crops under water scarce conditions in sub-Saharan Africa. *International Journal of Environmental Research and Public Health* 12(6):5685–5711.
Cloete J, Cloete S, Hoffman L. 2010. Behaviour of Merinos divergently selected for multiple rearing ability in response to external stimuli. *Small Ruminant Research* 60:227–236.
Cloete S, Olivier J, Sandenbergh L, Snyman M. 2014. The adaption of the South Africa sheep industry to new trends in animal breeding and genetics: A review. *South Africa Journal of Animal Science* 44:307–320.
DAFF [Department of Agriculture, Forestry and Fisheries]. 2016. *A Profile of the South African Traditional Medicines Value Market Chain*. Pretoria, South Africa: DAFF.
DAFF [Department of Agriculture, Forestry and Fisheries]. 2017. *Trends in the Agricultural Sector 2016*. Pretoria, South Africa: DAFF.
Davids YD. 2006. Poverty in South Africa: extent of access to food and income. *HSRC Review* 4:16–17.
de Beer PJ. 2009. *The Trophy Hunting Industry of South Africa: A Proposed Model to Ensure its Viable Future* [MSc thesis]. Pretoria, South Africa: University of Pretoria.
de Winnaar G, Jewitt GPW, Horan M. 2007. A GIS-based approach for identifying potential runoff harvesting sites in the Thukela River basin, South Africa. *Physics and Chemistry of the Earth, Parts A/B/C* 32:1058–1067.
De Wit MP, Blignaut JN, Knot J, Midgley S, Drimie S, Crookes DJ, Nkambule NP. 2015. *Sustainable Farming as a Viable Option for Enhanced Food and Nutritional Security and a Sustainable Productive Resource Base*. Synthesis report. Green Economy Research Report, Green Fund. Midrand, South Africa: Development Bank of Southern Africa.
Denison J, Wotshela L. 2009. *Indigenous Water Harvesting and Conservation Practices: Historical Context, Cases and Implications*. Water Research Council Report 392/09. Gezina, South Africa: Water Research Commission.
Dunnink JA, Curtis CJ, Beukes JP, van Zyl PG, Swartz J. 2016. The sensitivity of Afromontane tarns in the Maloti-Drakensberg region of South Africa and Lesotho to acidic deposition. *African Journal of Aquatic Science* 41:413–426.
Du Toit L, Meissner HH, van Niekerk W. 2013. Direct greenhouse gas emissions of the game industry in South Africa. *South African Journal of Animal Science* 43:376–393.
East African Community, UNEP, GRID-Arendal. 2016. *Sustainable Mountain Development in East Africa in a Changing Climate*. Arusha, Tanzania: East African Community; Nairobi, Kenya: United Nations Environment Programme; Arendal, Norway: GRID-Arendal.
Elleboudt R. 2012. *Are Conservation Agriculture Practices an Interesting Option for the Smallholder Farmer Communities of the Okhahlamba Local Municipality, KwaZulu-Natal, South Africa* [MSc thesis]? Gent, Belgium: Universiteit Gent.
Ellender BR, Weyl OL. 2014. A review of current knowledge, risk and ecological impacts associated with non-native freshwater fish introductions in South Africa. *Aquatic Invasions* 9(2):117–132.
Engdawork A, Bork HR. 2014. Long-term indigenous soil conservation technology in the Chencha area, southern Ethiopia: Origin, characteristics, and sustainability. *Ambio* 43:932–942.
FAO [Food and Agriculture Organization]. 2001.The importance of soil organic matter. Rome, Italy: FAO.
FAO [Food and Agriculture Organization]. 2015a. *Mapping the Vulnerability of Mountain Peoples to Food Insecurity*. Rome, Italy: FAO.
FAO [Food and Agriculture organization]. 2015b. *Understanding Mountain Soils: A Contribution From Mountain Areas to the International Year of Soils 2015*. Rome, Italy: FAO.
FAO [Food and Agriculture Organization]. 2016. *The State of World Fisheries and Aquaculture*. Rome, Italy: FAO
FAO [Food and Agriculture Organization]. 2019a. *Climate-Smart Agriculture 2019*. Rome, Italy: FAO.
FAO [Food and Agriculture Organization]. 2019b. *Mountain agriculture: Opportunities for Harnessing Zero Hunger in Asia*. Bangkok, Thailand: FAO.
FAO [Food and Agriculture Organization], IFAD [International Fund for Agricultural Development], WFP [World Food Programme]. 2013. *The State of Food Insecurity in the World: The Multiple Dimensions of Food Security*. Rome, Italy: FAO.
Gertenbach JJ. 1941. Necessity for terrace banks in arable land of the Orange Free State. *Farming in South Africa* 16(182):173–174.
Gobozi TKS. 2018. *Evaluation of a Peri-Urban Smallholder Farmers' Soil Amendment Practices on Soil Quality and Crop Growth, Yield and Quality* [PhD dissertation]. Stellenbosch, South Africa: Stellenbosch University.
Godfray HCJ, Beddington JR, Crute IR, Haddad L, Lawrence D, Muir JF, Pretty J, Robinson S, Thomas SM, Toulmin C. 2010. Food security: The challenge of feeding 9 billion people. *Science Journal* 327:812–818.
Gulzar M, Minnaar A. 2017. Chapter 12 – Underutilized protein resources from African legumes. *In:* Nadathur SR, Wanasundara JPD, Scanlin L, editors. *Sustainable Protein Sources*. San Diego, CA: Academic Press, pp 197–208.
Harden CP. 2013. Geomorphology in context: Dispatches from the field. *Geomorphology* 200:34–41. https://doi.org/10.1016/j.geomorph.2013.03.025.
Hawkins H-J. 2017. A global assessment of Holistic Planned Grazing™ compared with season-long, continuous grazing: Meta-analysis findings. *African Journal of Range and Forage Science* 34:65–75.
Hendriks SL, Viljoen A, Marais D, Wenhold F, McIntyre A, Ngidi M, van der Merwe C, Annandale J, Kalaba M, Stewart D. 2016. *The Current Rain-Fed and Irrigated Production of Food Crops and Its Potential to Meet the Year-Round Nutritional Requirements of Rural Poor People in North West, Limpopo, KwaZulu-Natal and the Eastern Cape: Report to the Water Research Commission and Department of Agriculture, Forestry & Fisheries*. Gezina, South Africa: Water Research Commission.
Hilger T, Keil A, Lippe M, Panomtaranichagul M, Saint-Macary C, Zeller M, Pansak W, Dinh TV, Cadisch G. 2013. Soil conservation on sloping land: Technical options and adoption constraints. *In:* Fröhlich HL, Schreinemachers P, Stahr K, Clemens G, editors. *Sustainable Land Use and Rural Development in Southeast Asia: Innovations and Policies for Mountainous Areas*. Berlin, Germany: Springer, pp 229–279.
Jaenicke H, Lengkeek A. 2008. Marketing the products of underutilized crops – challenges and opportunities for pro-poor economic development. *Acta Horticulturae* 770:87–94. https://doi.org/10.17660/ActaHortic. 2008.770.9.
Jewitt D, Goodman PS, Erasmus BFN, O'Connor TG, Witkowski ETF. 2015. Systematic land-cover change in KwaZulu-Natal, South Africa: Implications for biodiversity. *South African Journal of Science* 111 (9–10):2005-0019. https://doi.org/10.17159/sajs.2015/20150019.
Khwidzhili RH, Worth SH. 2016. The sustainable agriculture imperative: Implications for South African agricultural extension. *South African Journal of Agricultural Extension 44*(2):19–29.
Klein AM, Vaissiere BE, Cane JH, Steffan-Dewenter I, Cunningham SA, Kremen C, Tscharntke T. 2007. Importance of pollinators in changing landscapes for world crops. *Proceedings of the Royal Society B: Biological Sciences* 274(1608):303–313.
Knight J, Grab SW, Carbutt C. 2018. Influence of mountain geomorphology on alpine ecosystems in the Drakensberg Alpine Centre, Southern Africa. *Geografiska Annaler, Series A, Physical Geography* 100:140–162.
Kohler T, Wehrli IA, Jurek M. 2014. *Mountains and Climate Change: A Global Concern*. Bern, Switzerland: Centre for Development and Environment (CDE), Swiss Agency for Development and Cooperation (SDC), and Geographica Bernensia.
Körner C. Ohsawa M. 2005. Mountain systems. *In: Ecosystems and Human Well-being-I. Current State and Trends*. Millennium Ecosystem Assessment Series Vol 5. Washington, DC: Island Press, pp 681–716.
Lawes M, Adie H, Harriet E, Johan K, Wethered R. 2007. *An Assessment of the Forests of the Maloti-Drakensberg Transfrontier Bioregion, With Reference to Important Ecosystem Processes*. Scottsville, South Africa: Forest Biodiversity Research Unit, School of Biological and Conservation Sciences, University of KwaZulu-Natal.
Le Roux A, Mukwada G, Lombard C. 2018. The Afromontane Research Unit–growing as a hub of transdisciplinary research. *Mountain Research and Development* 38:85–87.
Le Roux J, Smith H. 2014. Soil erosion in South Africa - its nature and distribution. Grain SA. https://www.grainsa.co.za/soil-erosion-in-south-africa—its-nature-and-distribution; accessed 12 March 2020.
Mabhaudhi T, Chibarabada T, Chimonyo V, Murugani V, Pereira L, Sobratee N, Govender L, Slotow R, Modi A. 2019. Mainstreaming underutilized indigenous and traditional crops into food systems: A South African perspective. *Sustainability* 11:172.
Mabhaudhi T, Chimonyo VGP, Chibarabada TP, Modi AT. 2017a. Developing a roadmap for improving neglected and underutilized crops: A case study of South Africa. *Frontier Plant Science* 8:2143.
Mabhaudhi T, Chimonyo VGP, Modi AT. 2017b. Status of underutilized crops in South Africa: Opportunities for developing research capacity. *Journal of Sustainability* 9(1569):1–21.
Mabhaudhi T, O'Reilly P, Walker S, Mwale S. 2016. Opportunities for underutilized crops in southern Africa's post–2015 development agenda. *Sustainability* 8:302.
Mahlobo BT. 2016. *Multi–Criteria Livestock Assessment for Sustainability of Smallholder Farms in Kwa-Zulu Natal* [PhD dissertation]. Stellenbosch, South Africa: Stellenbosch University.
Mander M. 1998. *Marketing of Indigenous Medicinal Plants in South Africa*. Rome, Italy: Food and Agricultural Organization.
Mapeshoane BE. 2013. *Soil Hydrology and Hydric Soil Indicators of the Bokong Wetlands in Lesotho* [PhD dissertation]. Bloemfontein, South Africa: University of the Free State.
Martelize N. 2008. On the climate of the Drakensberg: Rainfall and surface-temperature attributes, and associated geomorphic effects. *Environments* 28:79–92.
MDTP [Maloti Drakensberg Transfrontier Programme]. 2008. *Sehlabathebe National Park Management Plan First Edition 2008–2013*. Maseru, South Africa: NES [National Environment Secretariat Maseru].
MDTP [Maloti Drakensberg Transfrontier Programme]. 2015. *Maloti Drakensberg Transfrontier Programme: Witsieshoek Proposed Community Conservation Area Concept*. Maseru, South Africa: NES [National Environment Secretariat Maseru].
Meadows ME, Hoffman MT. 2002. The nature, extent and causes of land degradation in South Africa: Legacy of the past, lessons for the future? *Area* 34(4):428–437.
Mekbib SB, Olaleye AO, Johane M, Wondimu T. 2017. Indigenous knowledge to address the challenges of climate change: Case of Machobane Farming System in Lesotho. *In:* Mafongoya PL, Ajayi OC, editors. *Indigenous Knowledge Systems and*

Climate Change Management in Africa. Wageningen, The Netherlands: CT, pp 140–159.
Moffett R. 2016. *Basotho Medicinal Plants–Meriana ya Dimela Tsa Basotho*. Bloemfontein, South Africa: African Sun Media.
Mohamed AA. Mukwada G. 2019. Temperature changes in the Maloti-Drakensberg region: An analysis of trends for the 1960–2016 period. *Atmosphere* 10(8):471.
Mosenene L. 2002. Promoting the Machobane farming system: An interview with Letla Mosenene, an advisor to farmer innovators in Lesotho. *Mountain Research and Development* 22:19–21.
Mukwada G, le Roux A, Hlalele D, Lombard C. 2016. The Afromontane Research Unit (ARU) in South Africa. *Mountain Research and Development* 36(3):384–386.
Mukwada G, Manatsa D. 2018. Spatiotemporal analysis of the effect of climate change on vegetation health in the Drakensberg Mountain Region of South Africa. *Environmental Monitoring and Assessment* 190:358.
Msuya TS, Kideghesho JR, Mosha TC. 2010. Availability, preference, and consumption of indigenous forest foods in the Eastern Arc Mountains, Tanzania. *Ecology of Food and Nutrition* 49(3):208–227.
Ndoro JT, Hitayezu P. 2014. Drivers of cattle commercialization in rural South Africa: A combined test of transaction cost and store-of-wealth hypotheses. *Agrekon* 53:57–78.
Ndoro JT, Mudhara M, Chimonyo M. 2014. Livestock extension programmes participation and impact on smallholder cattle productivity in KwaZulu-Natal: A propensity score matching approach. *South Africa Journal of Agricultural Extension* 42:62–80.
Nel W, Reynhardt D, Sumner P. 2010. Effect of altitude on erosive characteristics of concurrent rainfall events in the KwaZulu-Natal Drakensberg. *Water South Africa* 36: 509–512.
Nüsser M, Grab S. 2002. Land degradation and soil erosion in the Eastern Highlands of Lesotho, Southern Africa. *Pastoral Ecology* 21:291–311.
OVK Retail Division. 2019. *Emerging Farmers Support: One Household One Hectare in Agriculture* [Report paper]. https://pmg.org.za/committee-meeting/28844/; accessed on 6 January 2020.
Peden MI. 2004. *The impact of communal land-use on the biodiversity of a conserved grassland at Cathedral Peak, uKhahlamba-Drakensberg Park, South Africa: implications for sustainable utilization of montane grasslands* [PhD dissertation]. Pietermaritzburg, South Africa: University of KwaZulu-Natal.
Porter V. 2016. *Masons World Encyclopedia of Livestock Breeds and Breeding: 2 Volume Pack*. West Sussex, United Kingdom: CABI, p 1014.
Rassool C, Witz L. 1996. South Africa: A world in one country. Moments in international tourist encounters with wildlife, the primitive and the modern [Afrique du Sud: le monde en un pays. Instants de rencontres du touriste international avec le monde sauvage, le primitif et la modernité]. *Cahiers d'Etudes africaines* 36:335–371.
Rodrigues JB, Schlechter P, Spychiger H, Spinelli R, Oliveira N, Figueiredo T. 2017. The XXI century mountains: Sustainable management of mountainous areas based on animal traction. *Open Agriculture* 2:300–307.
Salomon ML. 2011. *Keeping Cattle in a Changing Rural Landscape: Communal Rangeland Management in Okhombe, KwaZulu-Natal* [PhD dissertation]. Pietermaritzburg, South Africa: University of KwaZulu-Natal.
SANBI [South African National Biodiversity Institute]. 2019. uMngeni Resilience Project farmers open a new food garden in Nhlazuka. https://www.sanbi.org/wp-content/uploads/2019/02/NIE-eSnippets-December-Edition1.pdf; accessed on 6 January 2020.
Schimmelpfennig S, Müller C, Grünhage L, Koch C, Kammann C. 2014. Biochar, hydrochar and uncarbonized feedstock application to permanent grassland–Effects on greenhouse gas emissions and plant growth. *Agriculture, Ecosystems and Environment* 191:39–52.
Sen K, Semwal R, Rana U, Nautiyal S, Maikhuri R, Rao K, Saxena K. 2002. Patterns and implications of land use/cover change: A case study in Pranmati watershed (Garhwal Himalaya, India). *Mountain Research and Development* 22:56–62.
Sert AN. 2017. Niche marketing and tourism. *Journal of Business Management and Economic Research* 1:14–25.
Shennan C. 2008. Biotic interactions, ecological knowledge and agriculture. *Philosophical Transactions of the Royal Society B: Biological Sciences* 363(1492):717–739.
Shezi TA. 2019. *Impact of Livestock Grazing Intensity on the Plant Diversity of Species-rich Montane Grassland in the Northern Drakensberg* [MSc dissertation]. Johannesburg, South Africa: University of the Witwatersrand.
Showers KB. 2006. *Soil Erosion and Conservation: An International History and a Cautionary Tale, in Footprints in the Soil*. Amsterdam, The Netherlands: Elsevier.
Shroyer ME, Blignaut P. 2003. Mountain conservation in South Africa. *In:* Watson A, Sproull J, compilers. *Science and Stewardship to Protect and Sustain Wilderness Values: Seventh World Wilderness Congress Symposium, 2001 November 2–8, Port Elizabeth, South Africa*. USDA Forest Service Proceedings RMRS-P-27. Ogden, UT: US Department of Agriculture, Forest Service, Rocky Mountain Research Station, pp 26–33.
Sibhatu K, Qaim M. 2017. Rural food security, subsistence agriculture, and seasonality. *PLoS ONE* 12:e0186406.
Skelton PH. 2000. Flagships and fragments—Perspectives on the conservation of freshwater fishes in southern Africa. *Southern African Journal of Aquatic Sciences* 25(1):37–42.
Stander H. 2009. Trout farming in South Africa: Expanding local markets work with ecotourism. Division of Aquaculture. *Salmonid* 38–40. https://www.was.org/magazine/search.aspx; accessed on 6 January 2020.
Street R, Prinsloo G. 2013. Commercially important medicinal plants of South Africa: A review. *Journal of Chemistry* 2013:205048.
Taylor S, Ferguson J, Engelbrecht FA, Clark V, Van Rensburg S, Barker N. 2016. The Drakensberg Escarpment as the great supplier of water to South Africa. *In:* Greenwood GB, Shroder Jr JF, editors. *Mountain Ice Water: Investigation of the Hydrologic Cycle in Alpine Environments*. Amsterdam, The Netherlands: Elsevier, pp 1–41.
Turpie JK, O'Connor T, Mills A, Robertson H. 2007. The ecological and economic consequences of changing land use in the southern Drakensberg grasslands: Environmental and ecological economics. *South Africa Journal of Economics and Management Science* 10:423–441.
Van Wyk A, Prinsloo G. 2018. Medicinal plant harvesting, sustainability and cultivation in South Africa. *Biological Conservation* 227:335–342.
Wittmayer JM, Büscher B. 2010. Conserving conflict? Transfrontier conservation, development discourses and local conflict between South Africa and Lesotho. *Human Ecology 38*(6):763–773.
WOCAT [World Overview of Conservation Approaches and Technologies]. 2007. *Mapping Land Degradation and Sustainable Land Management*. https://www.wocat.net/library/media/27/; accessed on 27 October, 2020.
Wymann von Dach S, Romeo R, Vita A, Wurzinger M, Kohler T. 2013. *Mountain Farming Is Family Farming: A Contribution From Mountain Areas to the International Year of Family Farming*. Rome, Italy: FAO; Bern, Switzerland: Centre for Development and Environment of the University of Bern; Vienna, Austria: Centre for Development Research of the University of Natural Resources and Life Sciences.
Yamane Y, Kularatne J, Ito K. 2018. Agricultural production and food consumption of mountain farmers in Tanzania: A case study of Kiboguwa village in Uluguru Mountains. *Agriculture and Food Security* 7:54. https://doi.org/10.1186/s40066-018-0207-z
Zondo SA. 2016. *Value Chain Analysis in the Proposed Witsieshoek Community Conservation Area (WCCA) in the Eastern Free State of South Africa* [Doctoral dissertation]. Qwaqwa, South Africa: University of the Free State.
Zunckel K. 2003. Managing and conserving southern African grasslands with high endemism: The Maloti–Drakensberg transfrontier conservation and development program. *Mountain Research and Development* 23:113–118.
Zunckel K. 2012. The Maloti Drakensberg Transfrontier Conservation and Development Project: A cooperative initiative between Lesotho and South Africa. *In:* Quinn MS, Broberg L, Freimund W, editors. *Parks, Peace, and Partnership: Global Initiatives in Transboundary Conservation.* Calgary, Alberta: University of Calgary Press, pp 283–307.