Mountains as a critical source of ecosystem services: the case of the Drakensberg, South Africa

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Acknowledgements

We wish to thank the National Research Foundation (NRF) who funded this work and Geldenhuys Sawmill, together with the Department of Agriculture, Forestry and Fisheries (DAFF), for providing facilities during the study. We also thank the Sethlare Tribal Council for the wise counsel and guidance.

Abstract

Mountain natural resource use and consequent ecosystem services for three diverse rural communities around the Mariepskop Mountain in the Mpumalanga Drakensberg, South Africa, were studied using interview and focus group discussions. The mountain provides a diverse range of critical ecosystem services to surrounding rural communities up to distances further than 20 km. Of the low income village-level households, 90% continuously depended on firewood and water. Commercial farmers valued mountain water and indigenous insect pollinators. For more affluent village inhabitants the aesthetic and historic values of the mountain are paramount. The ecosystem services identified by these three communities differed strongly with different community-specific ecosystem services. Ecosystem services identified by these communities were primarily influenced by household distance from the mountain and socio-economic status, with resource use decreasing with distance for most mountain resources with the exception of water. The importance of this mountain to livelihoods whilst ensuring resilience requires governance that takes into account socio-economic based diversity in the use of ecosystem services and spatial diversity of natural resources utilization.

Key words: natural resources; ecosystem services; socio-economic characteristics, rural livelihoods, mountains

1. Introduction

Mountains are important for natural resource provision such as water, fuel wood and raw materials to densely populated lowlands (Price 1998). These provisioning ecosystem services are used by rural communities as a source of food, medicine, energy and livelihoods. Other important ecosystem services provided by mountains include supporting, cultural and regulating services.

Tropical and subtropical areas in developing countries often experience excessive harvesting of common pool natural resources (Ostrom 2007; Bitariho and McNeilage 2008), through deforestation, overgrazing, and over-cultivation of soils (Armenteras et al. 2003; Beniston 2003; Ikkala 2011). This anthropogenic pressure causes protected resource rich mountain areas to experience constant illegal extraction of natural resources (Sheil et al. 2011). Management of natural resources by local authorities and communities and their ability to devise sustainable livelihoods and promote resilient ecosystems have become critical questions as a result (Falkenmark and Rockström 2010). Subtropical mountain ecosystems are subject to environmental effects due to high elevation, rainfall, steep slopes, and sensitivity to disturbances, making them susceptible to lower critical thresholds (UN 2002; Folke et al. 2010). These disturbances are expected to reduce the resilience of socio–ecological systems augmenting further exposure to hazards and uncertainties (Falkenmark and Rockström 2006).

Presently, most rural mountain communities have high population densities, low levels of education and high unemployment rates and this weighs heavily on natural resources (Beniston 2003; Gentle and Maraseni 2012). Most studies on natural resources have focused on resilience, vulnerability, governance and adaptability of socio-ecosystems, resource use and valuation (Banks et al 1996; Twine et al 2003; Agrawal and Gupta 2005; Ostrom 2007; Folke and Gunderson 2010). This is in reaction to the challenges of rural communities, which eventually lead to unsustainable livelihood practices (Shackleton 2001; Pollard et al. 2003; Twine 2011). There are fewer studies on the drivers of resource use particularly in sub-tropical Africa (Twine 2011) and even less on

mountain areas. There is a strong need to analyze socio-ecological interactions so as to understand natural resource use patterns and dependence on ecosystem services to foster more sustainable governance and livelihoods (Ostrom 2007). At the same time, the study of mountain areas provides a critical understanding of how these complex socio-ecological systems are interlinked and their impact on the larger ecosystems in the world.

Within the above context, a mountain site was selected with a number of socio-economically and culturally different communities. The objectives of the study were to identify the ecosystems services of different communities around the mountain and assess how their socio-economic characteristics influence their mountain natural resource use patterns. Such objectives require that ecosystem services should be defined. Ecosystem services are components of nature, directly enjoyed, consumed, or used to yield human well-being (Boyd and Banzhaf 2007). Hence, ecosystem services are defined as the direct or indirect benefits that humans obtain from using the natural resources provided by their natural environment.

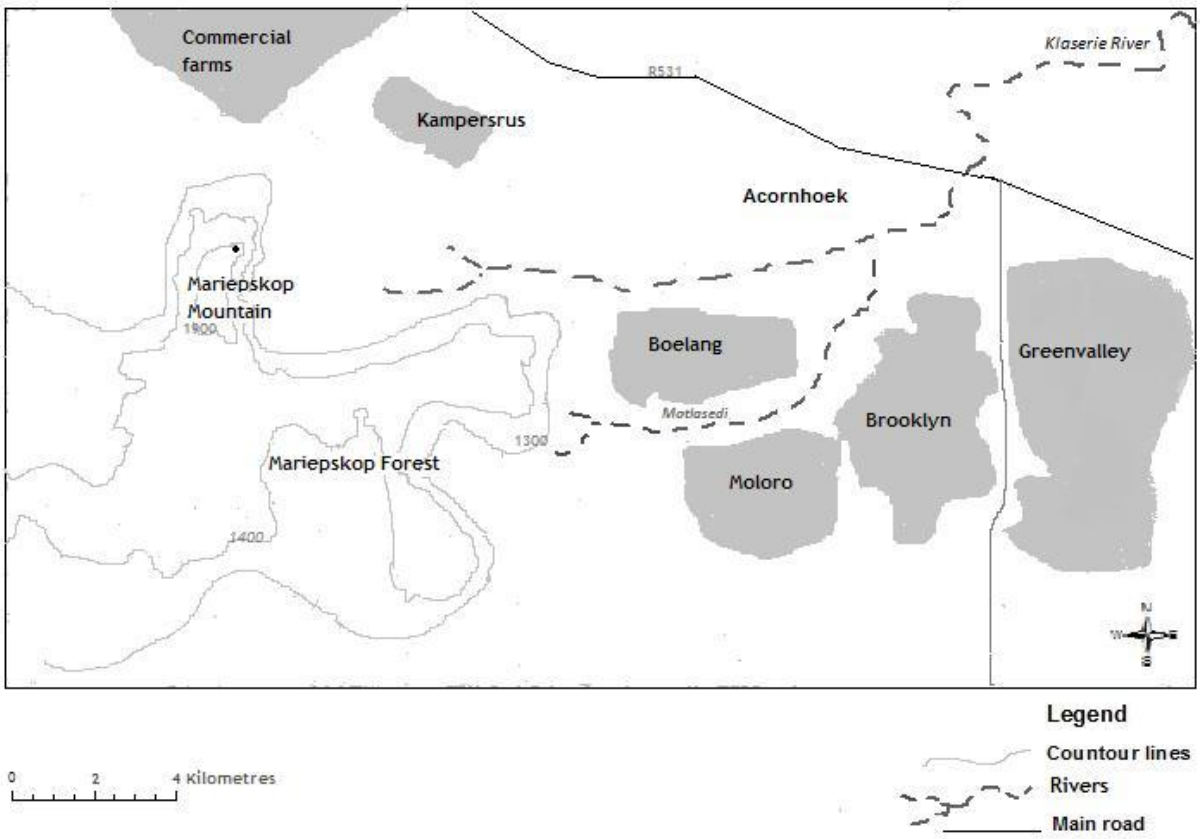
The specific objectives of the study were to, (i) identify the ecosystem services provided by the mountain for the different communities living around the mountain, (ii) access the importance of the Mariepskop Mountain in providing provisioning services such as drinking and irrigation water, agricultural and non-timber forest products; regulating and supporting services such as biodiversity, soil formation and water purification; cultural services such as spiritual, recreation, traditional ecosystem services to the surrounding communities, (iii) examine the factors that determine dependency on natural resources and ecosystem services.

2. Materials and methods

2.1 Study site

The Mariepskop Mountain (24°32'34''S, 30°52'07”E) straddles the border of Mpumalanga and Limpopo provinces, South Africa (Figure 1). Reaching an altitude of

Fig 1 Map showing the location of Mariepskop, the commercial farms, Kampersrus,and the main villages forming Acornhoek



1945 metres, it forms part of the northern Drakensberg Escarpment known as the Mpumalanga Drakensberg. The physiognomy of natural vegetation at the bottom of the mountain is typical of a wooded savanna. Tree density increases with altitude and changes to mist belt indigenous forest from about 1000 to 1900m asl, above which it progressively becomes evergreen shrubland similar to the Cape Fynbos (Mucina and Rutherford 2006). The south-eastern part of the mountain includes the remnants of extensive forestry closed in 2004 when the South African government decided to make the mountain a protected area. The plantation formerly comprised *Eucalyptus* and *Pinus* species, on around 1681 ha (Van der Schijff and Schoonraad 1971) making up 33.5% of the total mountain area and together with the saw mill provided employment to people from the nearby villages.

The Klaserie River emanates from the south eastern-slopes of the Mariepskop whilst the Blyde River cuts across the mountain on its north-western side and drains large parts of the plateau to the south west. Annual rainfall averages 1500 mm on the top of the mountain and 750 mm at the bottom. Mean summer mountain temperatures are around 24°C and mean winter temperatures around 18°C. A study of the mountain's soils show rocky soils at the mountain top with red clays in the middle zone and sandy substrates at the bottom.

This study included three human communities with spatial, cultural, socio-economic and population differences. Firstly, Acornhoek (which in this paper will be representing the villages of Boelang, Greenvalley, Brooklyn, Moloro and Arthurseat, located between the Mariepskop and the Acornhoek shopping centre) lies to the east of Mariepskop within the Bushbuckridge Municipality in Mpumalanga Province. It is a former homeland and has a high population density of 150-300 people km^2 (Shackleton et al. 1998; Pollard et al. 2003), with high levels of chronic poverty and pressure on local natural resources (Twine 2011). Household plots average 0.2 ha and most households perform rainfed subsistence farming, typically vegetables, fruits and maize (*Zea mays*).

Irrigation and game farmers represent the second community, scattered on the north and north-western side of the mountain. The commercial farmers, with properties ranging from ten to 2300 ha mainly grow citrus trees, horticultural crops and some game farming.

Lastly, the area also includes a small village (Kampersrus) at the northern foothills of the mountain, mostly comprising retired commercial farmers, small business owners and government employees.

2.2 Methods

An important aspect of the study was to compare the ecosystem services used by the three communities surrounding the mountain. This was achieved by collecting data from commercial farmers, Kampesrus residents and Acornhoek households. The Acornhoek household survey was along a distance gradient up to 21 km from Mariepskop, this is the estimated distance from the mountain to the periphery of the study area. Kampersrus and commercial farmers sample sizes were 20 households and 30 farms respectively and this made it difficult to compare with the larger sample size from Acornhoek (200 households). This study was more focused on Acornhoek household resource use patterns and their socio-economic characteristics because of the high population density and poverty levels in comparison to Kampersrus and commercial farmers. These factors increase the risk and vulnerability of the Mariepskop Mountain to resource over-exploitation. Studies have found that high population areas have high energy demands and firewood is the primary source of energy used in rural African households for heating and cooking (Banks et al. 1996; Madubansi and Shackleton 2007; Wessels et al. 2013).

2.2.1 Acornhoek household survey

Firstly, questionnaire-based survey of 200 households was performed focusing on socio-economic characteristics (age, gender, income, distance from mountain and household size) and trends in their resource use patterns. An interview process was

performed in the five villages and conducted in the local languages, with either the head of the household or their spouse depending on availability at the time of the interview. The five villages selected were closest in proximity to the mountain and likely to have more interactions with the mountain than villages further away. The University of Pretoria ethical procedures were followed and ethical clearance was obtained before the survey was commenced. The local authorities and interviewees were fully informed and consented to the interview process beforehand. Systematic sampling was used and every tenth house (Shively 2011) from an updated house list from the local municipality was selected for the interview. The questionnaire was structured such that the most pertinent issues were addressed more than once in different ways to test for consistent responses. To capture the natural resources obtained by the households a mixture of open-ended and closed-ended questions were used in the questionnaire. For analysis, data were grouped into socio-economic categories, age of household head (20-39, 40-59 and 60-99 years) and distance from the mountain (0-5, 5.1-10, 10.1-15, and 15.1-21 km). This distance clustering represents progressively increasing difficulty in travelling to collect any particular natural resource from the mountain. With income, the grouping was done to represent the poorest households earning less than ZAR (South African Rand) 1000 per month, followed by ZAR 1001-2000, ZAR 2001-3000 and lastly those above ZAR 3000.

Secondly, following the initial household interviews, three focus group discussions were held at the community halls in Greenvalley, Boelang (including Moloro) and Brooklyn villages. The groups included 25 to 35 voluntary participants clustered into homogenous sub-groups of ages and gender to encourage free discussion, participation and interaction. In a rural setting where gender roles are clearly defined and men seem to have more influence on decision making as they are viewed as the household heads, heterogeneous groups may have led to some women refraining from fully expressing themselves. Similarly, young people who openly disagree with elders may be viewed as disrespectful in these communities hence homogenous sub-groups were necessary to get a holistic picture and understanding of the people's perceptions and challenges. The information acquired was largely qualitative and each sub-group had to share its

dialogue with the rest of the meeting which corroborated or contradicted the findings. The individual groups also drew maps and diagrams of their villages showing the location of their most valued natural resources relative to their homesteads (ARD 2009) and for what purposes each of these resources were used. These qualitative results form an essential part of this study and were analysed concurrently with the quantitative data.

2.2.2 Farm and residential area surveys

Thirty commercial farms and conservation areas were selected from an updated farm list from the local district municipality. Every third farm was chosen and an interview performed using a questionnaire to establish which natural resources farmers derive from the mountain, how these resources are used and the level of dependence. Both qualitative and quantitative data were collected and the latter data were grouped into percentages and represented in a graph.

Finally, 20 respondents from Kampersrus (every second household chosen from an updated house list) were interviewed using a questionnaire to get an understanding of the benefits that the community derived from mountain natural resources. The information obtained from these interviews also included both qualitative and quantitative data using open-ended questions. The quantitative data were represented as percentages in a graph as well.

2.2.3 Data analysis for close ended questions

The data obtained from the Acornhoek survey were both qualitative and quantitative: binomial, ordinal and continuous values. The five major independent variables were age, sex, income, distance from the mountain and household size. A generalized linear model (glz) was used to analyse the data set for resource use against the independent variables (socio-economic characteristics). Statistical analyses were performed with R version 2.13.0 (The R Core Team 2011) on the dependent and independent variables, using a logit transfer function. The principal reason for using the logit transfer function

was due the categorical and binary data of the independent and dependent variables respectively. The output from the logistic regression gave the coefficients and the z-values. The Wald test was used to determine if the independent variable had a significant effect on the dependent variable ($p<0.05$) or not ($p>0.05$), because it is simple and easy to calculate.

2.2.4 Ecosystem services

The ecosystem services identified as important by the households at Acornhoek, Kampersrus and commercial farmers were listed including those they were generally unaware of. Identification of ecosystem services and their categorization used was similar to that used in the Millennium Ecosystem Assessment Synthesis (2005).

3. Results

3.1 Acornhoek socio-economic characteristics and resource use

The results here are discussed from individual natural resources perspectives and their ecosystem services. The natural resources that the Acornhoek community directly derives from the Mariepskop Mountain included water, firewood, poles, wild edible plants and herbs, reeds, sand and scenic beauty (Figure 2a) and these results include resources only collected from the mountain. A total of 93.5% of households in Acornhoek have access to electricity.

3.2 Natural resource use on local farms

Commercial farmers use the surface water primarily for crop irrigation whilst the game farmers use water mainly for watering their game animals. Commercial farmers use irrigation systems such as micro, drip and pivot irrigation mostly for citrus trees. About 80% of farmers cited a high dependence on water from the Blyde River for the adequate growth of their crop and therefore water quantity and quality is of principal concern (Figure 3a). The Mariepskop Mountain's scenic beauty was mentioned by 70%,

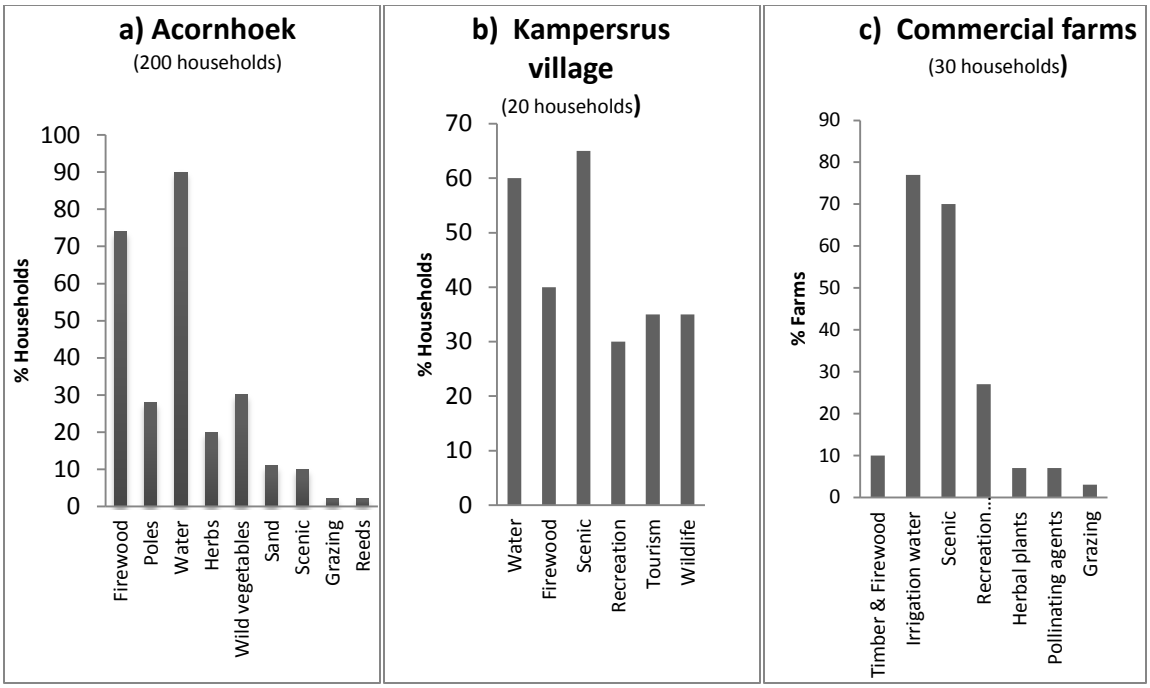


Fig 2 Acornhoek, Farm and Kampersrus mountain resource use patterns, reflecting the resources that were mentioned as being very important.

recreation and tourism by 30% and timber by 10% of the farmers. The mountain's function in the regulation of climate and providing pollinating agents was cited as important by 7% of the farmers.

3.3 Natural resource use by Kampersrus residents

Kampersrus residents who cited use of mountain water for household purposes were about 60% and 65% cited the importance of mountain scenic beauty and the mountain being the reason for settling there (Figure 3b). The mountain also acts as an important source of firewood for around 40% and recreation for 30% of the residents by providing picnic spots. Some restaurant and lodge owners mentioned that hiking and birding activities on the Mariepskop attracted tourists and boosted their businesses in the village. Furthermore, the mountain also has historical importance to the people of Kampersrus.

3.4 The effects of socio-economic categories in Acornhoek

The socio-economic characteristics that had a significant effect on mountain resource use patterns in Acornhoek were age, household size, distance and income. Distance has a more pervasive effect on the use of natural resources than any of the other independent variables (Table 1). The distribution of income reflects that 64% of households in Acornhoek earned ZAR 2 000 or less per month. This total income includes grants, pensions, remittances and earnings from wages and self employment. Households earning less than ZAR 1 000 were the most dependent on natural resources from the mountain.

3.5 The natural resources used in Acornhoek:

Water: Acornhoek households use water from the mountain for basic domestic uses (food and sanitation). The community uses five sources of water which include rivers used by around 18% of the households, tanks by 8%, boreholes by 20%, piped water by 31% and springs by 23%. Households made use of more than one water source,

Table 1 Results from generalised linear models and coefficients indicating the socio-economic and geographic factors that affect use of water and other natural resources by Acornhoek community.

Resource	Age	Household Size	Gender	Income per capita	Income	Distance from mountain
Water	0.643	0.385	0.275	- 0.0056**	0.62	0.909
River	0.337	0.963	0.706	0.879	0.838	- 0.0025**
Tank	- 0.024*	0.071	0.576	0.788	0.318	- 0.028*
Piped	0.501	0.587	0.697	0.589	0.589	0.062
Borehole	0.719	0.939	0.829	0.036*	0.842	0.743
Spring	0.068	0.954	0.136	0.191	0.563	0.40
Firewood	0.582	0.843	0.245	0.818	0.085	- 0.0001***
With vehicle	0.807	0.0076**	0.207	0.677	0.801	- 0.013*
Without vehicle	0.703	0.652	0.838	- 0.024*	0.777	0.882
Poles	0.628	0.150	0.464	0.524	0.72	- 0.0038**
Herbs	0.412	0.041*	0.726	0.076	0.201	0.610
Wild vegetables	0.632	0.807	0.493	0.461	0.083	- 0.0021**
Sand	0.719	0.948	0.551	0.189	0.972	0.408
Scenic beauty	0.503	0.754	0.229	0.084	0.26	0.135
Grazing	0.0198*	0.736	0.999	0.691	0.645	- 0.0061**
Reeds	0.098	0.593	0.236	0.013*	0.069	0.065

*Significant values marked with an asterisk.

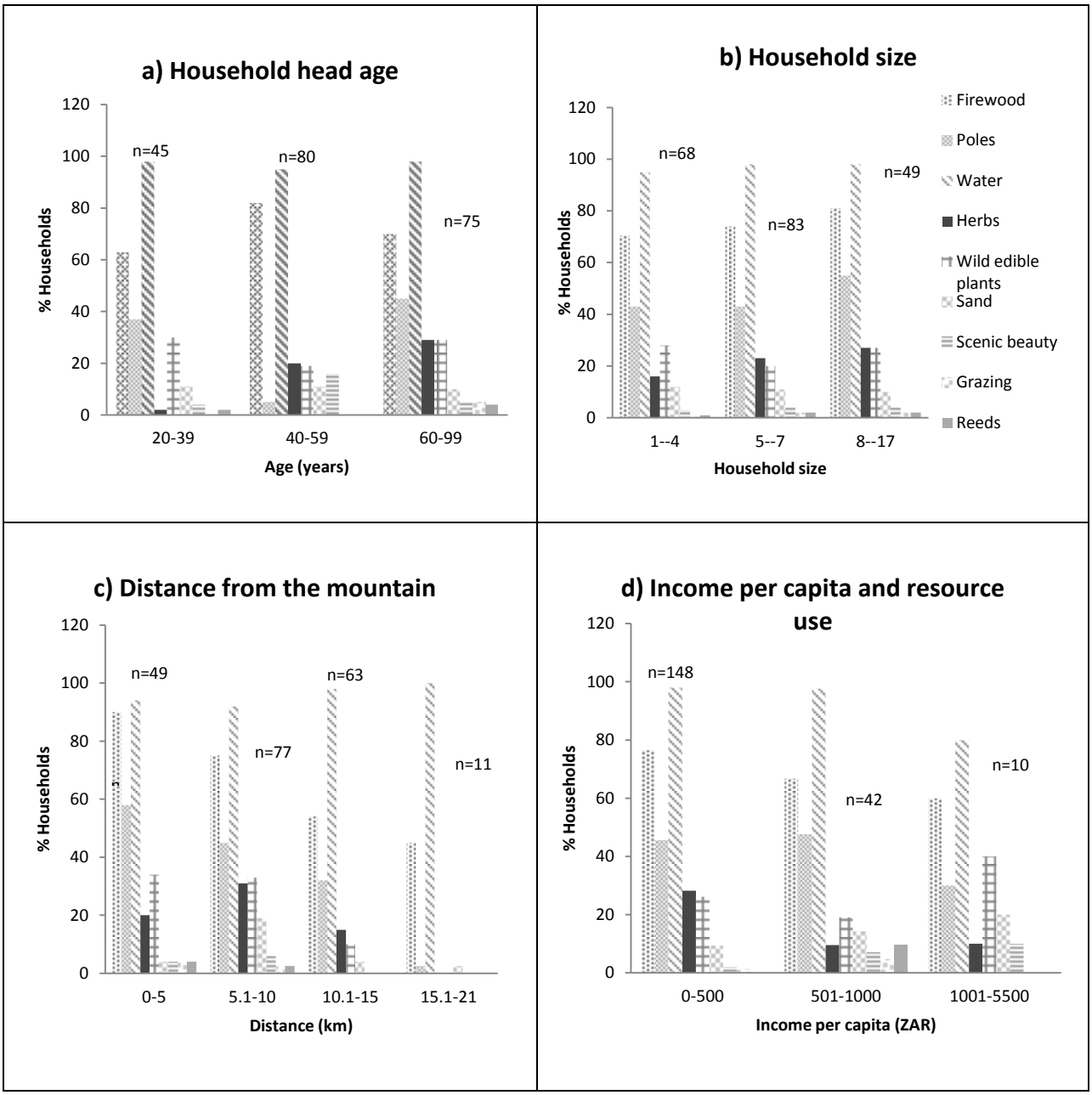


Fig 3 Factors affecting resource use by the Acornhoek community: a) Age of household head, b) Household size, c) Distance from mountain (km), d) Monthly income per capita (ZAR)

depending on water availability. They use untreated water from tanks filled from community reservoirs such as the Acornhoek Dam. Distance from the mountain had a significant negative effect on the direct use of rivers and tanks as water sources (Table 1). Age had a significant negative effect on the use of tank water. Also, there is a significant positive relationship between the total income of a household and the use of boreholes as a water source, with more affluent households at Acornhoek sinking their own boreholes (Table 1).

Firewood: The Acornhoek community uses firewood as a primary energy source especially for cooking and heating while electricity is used largely for lighting and electrical appliances such as radio or television. Collection of firewood from the mountain is done mainly using a vehicle by 70% of households with frequency ranging from once every month to once every three months and using head-load or wheelbarrow by 20% of households daily. The 20% of households that collect firewood using head-load or wheelbarrow either live within 5 km from the mountain or earn a low total household income. The remaining 10% of the households use mainly electricity and paraffin to meet their energy requirements. The number of times firewood is collected by a household per month begins to decline at a distance further than 5 km from the mountain (Figure 3c). There is significant inverse relationship between the number of times firewood is collected by head-load or wheelbarrow, that is, without a vehicle, and the total income earned by a household (Table 1).

However, there is a 3 way statistical interaction between age, distance, and total income on the number of times firewood is collected without using a vehicle (Wald $z=2.32$, $p=0.022$). Age, distance and total income do not act independently with prior emphasis on a two-way interaction between distance and income. Age and distance correlate inversely with total income. As distance, age and total income increase they interact to reduce the number of times firewood is collected by head-load or wheelbarrow. There is a significant negative relationship between distance from the mountain and number of firewood collection using a vehicle (Table 1). In addition, there is a significant positive relationship between the size of a household and the number of firewood collections

Table 2 Ecosystem services across communities surrounding the Mariepskop Mountain and communities further away, near the KNP, according to the present study and previous studies in Bushbuckridge. Ecosystem services marked with asterisks (*) are considered important by the different communities

Acornhoek		Commercial farmers		Kampersrus		Proximate to the KNP	
***Water**– Potable water directly from rivers and springs	90 % of households use water from the mountain for domestic purposes.	***Water** Irrigation water	80% of the farmers use water from the Blyde and Klaserie Rivers for irrigation. Farm households use borehole for domestic use.	***Water** – Potable water from Mariepskop for domestic use	60% of the residents at Kampesrus identified the mountain as important for providing water	**Energy** – Firewood for cooking and heating obtained from mountain	Poor households sometimes collect firewood and water in the forest next to the mountain, a long distance away, instead of purchasing the resources (Hunter, Twine, and Johnson 2011). Wood supply increases as distance from the villages increases (Banks *et al*. 1996) Areas more than 1200 m from settlements had double the biomass of the conservation areas (Wessels *et al*. 2013)
***Energy** - Firewood for cooking and heating purposes	75% of the households in Acornhoek use firewood collected from Mariepskop for cooking and heating. Households use 3-4 tonnes of fuelwood per annum (Madubansi and Shackleton, 2007)	***Pollination** – pollination of citrus fruit trees by pollinators such as bees and flies	10% of the farmers stressed the importance of pollinating agents	***Energy –** Used for recreation	Firewood for recreational barbeques	**Water** – Potable water for the poor households.	Villages experience less rainfall, which may lead to increased crop failure (Shackleton *et al*. 1998)
***Shelter** – Building materials: sand and poles	28% of households collecting poles and 11% of households collecting sand for construction from the mountain.	***Aesthetic** – Visual beauty of the mountain	70% of the farmers regarded the aesthetic beauty of the mountain as important	***Aesthetic** – The beauty of the mountain	65% of residents thought the beauty of Mariepskop was very important	**Nutrition –** Wild edible plants (fruit, vegetables & herbs) to supplement income	A wider variety of wild edible plants is collected in villages with higher Mean Annual Rainfall (MAR) than in villages with lower MAR (Shackleton *et al*. 1998)
***Nutrition** – Wild edible fruits and herbs	25% of households collect wild edible plants from the mountain	***Recreation and tourism** A place where people go for picnics, bird	27% of the farmers identified the mountain as a source of	***Recreational** Recreation, hikes and swimming	35% of residents believe the mountain is important for recreation,		

		watching and other recreational activities	recreation and tourism		tourism and wild life conservation		
***Traditional/ Heritage** – Important cultural customs that all youths have to attend e.g. initiation schools and rituals on the mountain	Residents of Acornhoek feel attached to the mountain because of the presence of ancestral graves and the history of the area			**Heritage** – Historical importance	Ancestors' graves on the mountain		

using a vehicle (Table 1).

Grazing: Cattle owned by Acornhoek households graze on the Mariepskop Mountain. There is a significant negative relationship between the use of grazing as a natural resource and distance from the mountain (Wald z=-2.770, p=0.0061). There is also a positive significant relationship between grazing and age of household (Wald z=2.348, p=0.0198), since older people own most of the livestock.

Herbs: Herbs from the mountain are widely used by rural households in traditional ceremonies and for medicinal purposes. These include *Helichrysum adoratissimum, Hypoxis hemmerocallidea* and *Siphonochilus aethiopicus* species. There is a significant positive relationship between size of the household and the use of herbs (Wald z=2.058, p=0.041). Older people between 60 and 99 years are more dependent on herbs from the mountain (Figure 3a). Households with the least income per capita of less than ZAR 500 use the most herbs (Figure 3d).

Wild edible plants: Wild vegetables and fruits are collected mainly to supplement food, the most common are *Corchorus* species*, Momordica balsamina* and *Amaranthus* species. Households close to the mountain use more wild edible plants (Wald z=-3.118, p=0.002) since distance had a highly significant negative effect on the use of wild vegetables (Table 1, Figure 3c).

Reeds: Reeds are collected from river banks for making mats, brooms and traditional ornaments. Wealthier families tend to use more reeds from the mountain than the poorer families (Wald z=2.462, p=0.013), products from reeds could be the source of income and the preferred resource for ornament making.

Scenic beauty: Age, household size, gender, income and distance all had no effect on the appreciation of scenic beauty. Cultural practices such as initiation schools for boys as they get into adulthood are held on the mountain by the Acornhoek community whilst other people go to the mountain for spiritual worship and upliftment.

Table 3 Ecosystem services (ESs) derived from the mountain and utilized by different communities around Mariepskop. ESs marked with an asterisk are considered important by the communities themselves. Additional ESs are also used by the communities as observed during this study.

	Acornhoek	**Commercial farmers**	**Kampersrus**	**Areas in proximity to KNP**
Provisioning	*Energy-Firewood *Nutrition-Water, wild edible plants & fruits *Shelter-poles, sand, thatch grass	*Energy –firewood for barbeques *Water-irrigation of citrus trees	*Energy- firewood for recreation *Water-for domestic consumption	Energy Nutrition
Regulating	*Clean water & air & higher rainfall Disease regulation Seed dispersal	*Pest control	Climate-higher rainfall	
Supporting	*Production- Soil formation subsistence farming Nutrient cycling	*Pollination- pollinating birds & insects Soil formation- deeper, fertile soils *Production Nutrient cycling		
Cultural	*Heritage-historical site, ancestors graves landmark Traditional-ceremonies *Spiritual	*Aesthetic *Heritage-historical site Recreational- hiking, swimming Spiritual	*Aesthetic *Heritage-historical site, ancestors graves *Recreational- hiking, birding, swimming *Tourism Educational Spiritual	Heritage-historical site

3.6 Acornhoek community perceptions on sustainable mountain ecosystem services

In Acornhoek, there was a clear understanding on the importance of the mountain as a source of firewood, poles and water depicted by the diagrams drawn by the different sub-groups in the focus group discussions. In all three discussions, water sources appear on diagrams in the form of rivers, tanks, taps and boreholes reflecting the importance of water. Mariepskop is also seen as historical landmark especially with the older generation. In one meeting some of the older participants expressed the hope of returning to live on the mountain, the reason for relocating being to be close to the ancestors buried there expressing its importance as a source of heritage and culture.

Pollution and social responsibility is seen as someone else's problem: Two focus groups had concerns about lack of refuse collection resulting in the pollution of rivers. In addition, these cited that lack of tertiary education and employment opportunities force the youth to seek livelihoods which may be unsustainable to the environment such as poaching, selling firewood and illegal sand mining. Importantly, there is little sense of responsibility towards the state of the mountain natural resources, for example, 80% of the interviewees responded that the government and local leadership were responsible for the mountain well-being. In addition, 56% wanted better access to the mountain and its resources, while 24% had no knowledge of what was happening there and 20% perceived that since the mountain still provided firewood there was no need for any changes or improvement in management. This may also be a reflection that the community of Acornhoek's lack of involvement in any Marieskop programmes in the past may have led to a lack of responsibility or interest towards the mountain.

Weaknesses in governance: The Acornhoek community strongly felt that the derelict pine and eucalyptus plantations on the Mariepskop should be re-opened to provide much needed employment and that such a step would decrease the dependence of households on natural resources and the corresponding ecosystem services. This feeling is accompanied by some resentment that the community was not consulted

about the land use change on the mountain. The tribal council and the local municipality are not directly involved in the decision making, monitoring and by-law enforcement on the mountain. This may explain why there were no public participation exercises conducted prior to the plantation closure which led to the Acornhoek people losing an important source of livelihood. Currently, the only active institution managing the mountain is the Department of Agriculture, Forestry and Fisheries (DAFF).

3.7 Perceptions of commercial farmers and Kampersrus communities

Commercial farmers had strong concerns on environmental changes which could alter the mountain ecosystems and impact negatively on ecosystem services including birds and insects which play a vital role in pollination of their fruit trees. Upstream illegal settlements and their associated activities were feared to potentially compromise water quality downstream of the Blyde River. The farmers advocated that the mountain becomes a conservation area to protect wildlife from extinction and maintain its aesthetic beauty and that forestry activities be resumed in order to provide much needed employment.

The Kampersrus community views the mountain in a conservationist manner preferring that it should remain a protected area where resource harvesting is strictly monitored to promote mountain sustainability.

4. Discussion

4.1 Ecosystem services differ widely among the cultural groups at Mariepskop

Residents of Acornhoek, Kampersrus and the commercial farmers obtain widely different benefits from the Mariepskop Mountain due to differences in socio-economic circumstances and sources of livelihood. Water is of great importance to all communities, albeit for different purposes. Commercial farmers are highly dependent on

irrigation water which is vital for the productivity of their land and the success of their agricultural businesses, whilst Kampersrus and Acornhoek households mostly use the water for domestic and sanitation purposes. This correlates with the study by Bernués et al. (2014) in the Mediterranean Mountains, where farmers gave more importance to ecosystem services directly linked to their farming activities for example, raw materials, fire prevention and soil fertility whilst citizens were more concerned with services connected to their well-being such as food, water purification and aesthetic.

Poorer communities depend more on essential ecosystem services. Having scenic beauty at a low 5% or less in Acornhoek reflects that survival takes precedence over aesthetics in poorer communities. This is apparent when the percentage of households who mention aesthetic beauty as a natural resource doubles in the highest per capita income class (ZAR1001-5500) in Acornhoek and also when compared to Kampersrus residents and commercial farmers. The cultural significance of the mountain was however emphasised by the people of Acornhoek as it is imbedded in the preservation of traditional practices such as initiation schools for the youth and traditional ceremonies. Cultural mountain ecosystem services are important to communities for spiritual, educational (Bernués et al. 2014), and traditional reasons (De Beer 1999). The cultural importance of the mountain for Kampersrus residents and commercial farmers is mainly in recreation ecosystem services.

Water: Water is the one mountain resource that is consistently used across all ages, distances, incomes and household sizes for different purposes. The role of the mountain in supplying regulating services such as water harvesting and purification is quite evident with both the Blyde and Klaserie Rivers classified as in very good ecological condition (DWA 2009). There is an increasing rainfall gradient towards the mountain (Banks et al. 1996; Wessels et al. 2013) as the Mariepskop provides climate and flood regulating ecosystem services.

4.2 Poverty and mountain resource use

Poorer households in Acornhoek are more dependent on mountain resources and their accompanying ecosystem services. Twine and Hunter (2011) found that natural resources serve as a safety net to rural households during times of disturbances or shocks such as droughts, floods and illness or death of a wage earner. Firewood, poles and water are essential to most of the Acornhoek households regardless of their monthly income. High poverty and unemployment rates are compounded by the historic socio-economic disadvantages of the community. Homelands were generally economically and politically marginalised areas located on less desirable lands with shallow soils (Shackleton et al.1998, Ngwato 2012). Today, households have access to small plots of land (Shackleton et al. 1998) on long-term leases to practice rainfed subsistence farming. The plots of land however cannot be formally sold or used as security in order to access loans from financial institutions for farming inputs and rainfed agriculture is vulnerable to droughts and climate change impacts. Commercial farmers on the other hand, have the distinct advantage of owning their large tracts of land and access to irrigation water. A study by Gentle and Maraseni (2012) on rural mountain communities in Nepal found similar results, that wealthier households had irrigated lands, savings, produced surplus food and access to loans by using the land as collateral whilst poor households had limited and non-irrigated lands in comparison, perpetuating the cycle of poverty.

High illiteracy rates in mountain areas increases the risk of over-exploitation of natural resources because better education gives a household more diversity in livelihood options, encourages socio-economic development and technology, and ecological sustainability (Rugumamu 2004, Gentle and Maraseni 2012). Poverty can lead to children having to drop out of school to work and contribute to household income or lacking access to training and tertiary institutions. As confirmed by the Acornhoek community, this also results in the over-harvesting and commercialization of mountain resources as livelihood alternatives. Therefore, low income and high poverty

households lead to unsustainable resource use patterns.

4.3 The future sustainability of Mariepskop Mountain natural resources

This study has found that as monthly income increases, Acornhoek households prefer using vehicles to collect firewood, due to increased in disposable income and convenience. However, the collection of firewood using a vehicle has similarities to commercialization due to large amounts of deforestation occurring in a short period of time. This situation may not allow sufficient time for mountain biomass regeneration which may lead to demand outstripping supply (Banks et al. 1996). Furthermore, with future population growth demand for firewood is likely to increase leading to further reduction in biomass levels (Wessels et al. 2013). This implies that Acornhoek households would have to find alternative sources of firewood and energy. Massive deforestation would inevitably cause soil erosion and reduced stream flow changing mountain ecosystem integrity through habitat destruction and biodiversity loss (Dessie and Kleman 2007).

Furthermore, overexploitation and degradation of natural resources reduces the capacity of the mountain to provide ecosystem services and also increases vulnerability to environmental change. Mountains channel water to rivers maintaining surface water systems (Dessie and Kleman 2007), their vegetation assists water infiltration into the soil replenishing groundwater systems. Mountain ecosystems are hotspots for global biodiversity and natural corridors for different species with their forests also acting as important carbon sinks (Körner and Ohsawa 2005).

4.4 Interactions and interlinkages of socio-ecological systems

According to Rugumamu (2004), environmental degradation is a reflection of socio-economic, political and ecological problems. Neglecting important interactions and linkages between the environment and socio-economic systems results in poor

mountain governance, that is, weak socio-economic systems eventually lead to weak socio-ecological systems. Therefore, strengthening socio-economic systems is likely to lead to more sustainable resource use patterns and hence stronger socio-ecological systems. What this study has revealed is that different communities have different interactions or resource use patterns due to socio-economic characteristics. Some of these linkages may however be more complex, for example, this study found that most resource use patterns in Acornhoek are not significantly affected by income. There are two possible reasons for this. Firstly, that resources such as firewood are so readily available and accessible that households really feel that paying for alternative energy sources would be an inconvenience. Secondly, that the levels of income in Acornhoek are overall rather low such that even the higher income households do not want or cannot afford to pay for alternative sources of energy for cooking and heating. Understanding these hidden dynamics is the key to fostering sustainable mountain resource use patterns and maintaining the flow of ecosystem goods and services. Mountain governance that does not take into account or fully understand how socio-economic systems affect resource use and ecological systems will not effectively implement sustainable management of natural resources.

5. Conclusion

Basic interactions of different communities with the mountain resource base, their resource use patterns, drivers, and the corresponding ecosystem services were explored in this study. The Mariepskop Mountain comprises a critical source of wide ranging natural resources and ecosystem services to all the communities living around it as far as 20 km away with distance having the most effect on resource use in Acornhoek. These communities depend on the mountain for the continued flow of ecosystem services. The surveys illustrated a strong relationship linking the poorer Acornhoek households, commercial farmers and Kampersrus community with the mountain, albeit for different reasons. This study has revealed how socio-economic characteristics can drive resource use patterns.

Commercialization and the use of vehicles for collecting firewood reflect highly unsustainable harvesting rates. Furthermore, deforestation coupled with steep slopes markedly increases the rate of soil erosion down the mountain washing away the nutrient rich topsoil and reducing soil quality. Sustainable mountain governance has to take into consideration the socio-economic diversity of local communities and spatial diversity of natural resource utilization. Once government and traditional institutions establish and understand mountain resource use patterns and their socio–economic drivers, they are able to make decisions that create more resilient communities and thus more sustainable ecosystems. This can be done through similar surveys and community participation in the decision making processes in mountain areas. Mountain governance structures can only be effective if they involve the very communities that are dependent on its ecosystem goods and services. This can be achieved through continuous research on the dynamic interactions and complexities of socio-ecological systems in developing strategies and decision making, avoiding a state of panacea as described by Ostrom (2007).

Socially and economically empowered people are more resilient and less directly dependent on natural resources. It is important for mountain areas all over the world such as the Mariepskop to develop governance approaches that reflect genuine understanding of socio-economic dynamics of local communities and include them in decision making, management and enforcement. Governance mechanisms that encourage socio-economic improvement for local communities are therefore necessary to reduce over-dependence and over-exploitation of mountain resources.

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