The “Invisible” Mountains

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Using GIS to Examine the Extent of Mountain Terrain in South Africa

This paper examines various ways in which mountains can be defined for Southern Africa (Lesotho, South Africa and Swaziland), and South Africa in particular, by using harmonized topographic, vegetation and cultural digital data within a Geographic Information System (GIS). A particular topographic model is finally selected. This definition is then applied to the South African national context to identify the socioeconomic characteristics of its mountainous areas, in particular with regard to poverty indicators. These areas are identified as having distinctive characteristics when compared with metropolitan areas and, more importantly, with non-mountain rural areas. This observation has important political implications, as mountains currently have a very low visibility in regional and social policy.

Keywords: *Definition of mountains; topography; vegetation; socioeconomic features; GIS; policy; South Africa.*

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Introduction

Following the global initiatives laid down at Rio in 1992, mountain regions were designated under Agenda 21 as important zones in which particular policy initiatives should operate. In South Africa the momentous political events of the 1990s provided an opportunity for government policies to be reassessed, and the term "sustainable development" was adopted to describe the objectives of some of these initiatives. However, while there are now a number of special initiatives for sustainable development (eg, Government of South Africa 2001), there is virtually no mention of mountain regions in these policies. It is as if the mountains of the region were invisible. This is rather curious, as many of the data now available from lower levels of the government (ie, departments) do refer to mountains in a wide range of contexts. However, major plans in this direction have not as yet materialized.

The "invisibility" of mountains in current South African policy may be due to the fact that they are considered an insignificant part of the total territory or seen as too sparsely populated to be of political importance. The reason may also lie simply in the relative weakness of a body of opinion that has been unable to ensure a higher profile for the mountains. Nevertheless, there is a growing body of literature and personnel who are campaigning for a more strongly recognized mountain focus in policy (Blignaut and Blignaut 1999). Deriving accurate estimates of the area of mountains is non-trivial because no simple definition of mountains exists, especially when placed in a specific national or regional context (Funnell and Parish 2001). It is essential for subsequent policy analysis that a working definition is obtained, and that, at the same time, its limitations in both derivation and interpretation are clearly understood.

Previous studies of the extent of mountain areas

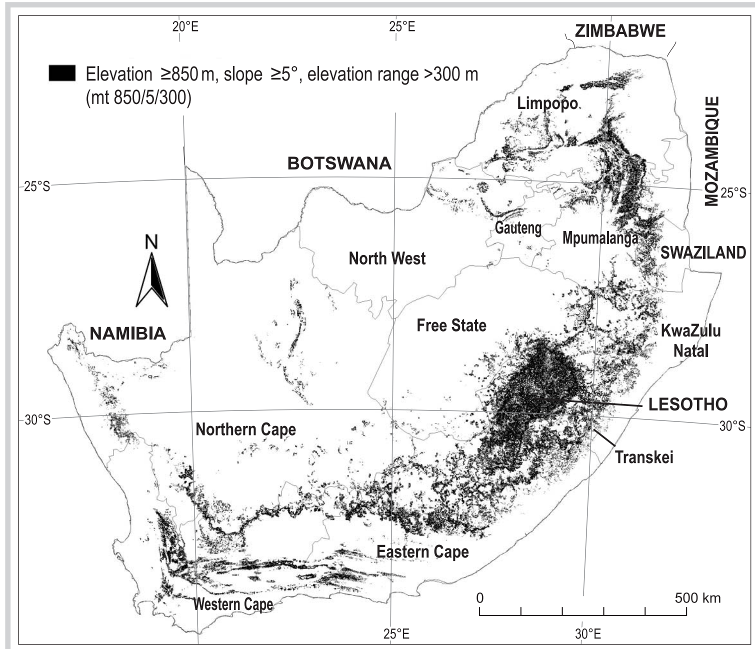
The most concise statement of geographical extent of mountains in Southern and South Africa is that by Rabie et al (1994). They examined the legislative framework for mountain areas in South Africa—the Mountain Catchment Areas Act 63 of 1970 provides the only legislative recognition of mountains, arising from the vital role that water plays in the South African economy—and noted the ambiguities surrounding their definition, according to which a lower limit might lie anywhere between 300 and 900 m. They then determined that 25% of South Africa could be classified as mountains, with 15% better considered as "hilly country, coastal escarpments and canyons." These 15% were therefore excluded. The remaining "main mountain areas," defined in terms of a minimum elevation of 450 m, consist of river catchments covering 9% of the country's territory, and isolated mountains, usually in arid zones, covering an additional 1%. Thus approximately 10% of South Africa could be considered as mountainous. Rabie et al (1994) draw these figures primarily from Kruger (1983), whose data are incorporated into the ENPAT (Environmental Potential Atlas for South Africa) data suite.

Kruger (1983) produced a classification of terrain morphology that has served as the basis for both the ENPAT digital database and work published in the recent Agro-Hydrology Atlas (Schulze 1997). The classification identifies a number of terrain divisions relevant to this analysis, based upon elevation, slope, and the extent of the area with slopes below 5%. Even allowing for the relative complexity of this classification, it produces an estimate for mountain areas in South Africa twice as big as that of Rabie et al (1994), despite the fact that both sources use a minimum elevation of 450 m.

Using digital data and GIS to explore different ways of defining a mountain

The present study examines 3 different ways of defining mountains for Southern and South Africa, using definitions based on topography, vegetation and cultural criteria. They are, of course, not mutually exclusive. A variety of widely available digital data sources are

FIGURE 1 Area of Southern Africa classified as mountainous according to the topography-based "mt850/5/300" definition. (Map by authors)



employed to explore the appropriateness of these definitions. The data were harmonized to the Albers Conic Equal-Area projection based upon the Clark 1886 Spheroid with the Central Meridian at 24° East and the Standard Parallels at –32° and –18° South. These parameters are particularly appropriate for the Southern African region. The software used were Arc/Info, ArcView, and Microsoft Excel.

Topography-based definitions of mountains

We used the digital topographic database GTOPO30 to derive revised evaluations of what constitutes "mountains." This database, constructed in 1996, has a horizontal grid spacing of 30 arc seconds, which translates into approximately 1 km. In practice this varies according to latitude. It has a vertical interval of 1 m. Its construction and limitations are described on the United States Geological Survey web site (USGS 2003). The resolution of the GTOPO30 data is widely considered to be of appropriate quality at a regional scale. It is employed by the authoritative United Nations Environment Programme World Conservation Monitoring Centre (UNEP–WCMC) for the derivation of mountain zones at a global scale (Kapos et al 2000), and a digital terrain model (DTM) has been derived, in which topographic categorization takes into account elevation, slope and elevation range.

Using this classification, Debarbieux et al (2000) have calculated that approximately 31.4% of Southern Africa and 29.4% of South Africa are classified as mountainous. However, as will be shown below, this global classification is not very accurate in capturing the altitudinal range appropriate for Southern Africa, and it exceeds the total derived from the non-GIS-based definitions noted above. It should also be recorded that Kapos et al (2000) underline the dangers of using their global classification at more local scales.

We therefore decided to produce a classification that is also based on GTOPO30 data, but is more sensitive to the particular topographic characteristics of Southern Africa. The first task was to identify an approximate elevation level at which it could be argued that mountain terrain is evident in the landscape. Accordingly, a hypsometric curve for Southern Africa was derived.

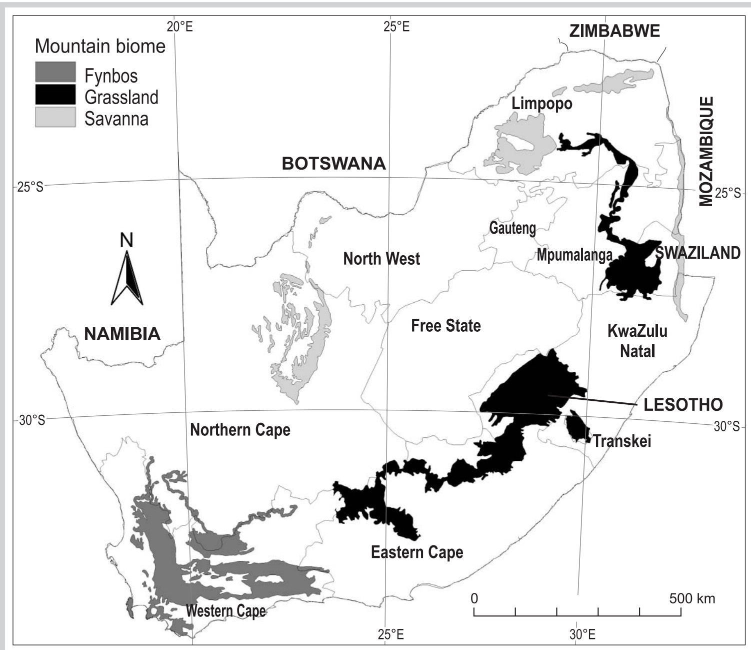
The interpretation of such curves is not straightforward (Short 2003), but can be construed as reflecting the processes responsible for producing landforms, eg, the extent of uplands dissection. The curve suggests that between 850 m and 1750 m, the landscape is more "rugged." The distinctive break point at approximately 850 m is therefore considered to be the lower limit of "mountains." However, this is merely a definition based on elevation. Account had to be taken of the extensive plateau coverage and the fact that in the context of Southern Africa, plateaus are socioeconomically distinct from mountains. In order to cope with this factor, we determined that our classification had to satisfy 2 additional constraints: local slope angles must be greater or equal to 5°, and the range of elevation (defined as the range within a radius of 7 cells) must exceed 300 m (Figure 1).

Based on this definition, the area classified as mountainous for Southern and South Africa is 9.76% and 8.3% respectively. The resultant map, though capturing much less than the Kapos model, is intuitively reasonable, identifying the Lesotho Highlands and the key scarps of South Africa. In addition, it shows the parallel features of the Cape Fold Mountains along with the ranges in the Western Cape.

Changing the elements of elevation, slope and elevation range will result in different mountain areas. In order to explore the extent of variation and test the sensitivity of the maps to such alterations, we performed a series of experiments. First, we examined the impact of changing the critical elevations, while retaining slope and elevation range. Despite moving the lower threshold from 850 m to 200 m, the mountain area only increased from 9.76% to 13.69%. We then varied the minimum slope gradient from 5° through 2°. This had a significantly greater impact at all elevations. For instance, at 850 m the mountain land increased from 9.91% to 23.4%.

Clearly, the development of a mountain map based on topography is highly conditional upon the specific

FIGURE 2 Area of Southern Africa classified as mountainous according to the vegetation-based "mountain biome" definition. (Map by authors)



criteria chosen. A number of alternative approaches have been used at the global level, for example by Meybeck et al (2001), but the task of identifying criteria that have some rationale at a more local level remains difficult. Kapos et al (2000) acknowledged that their differential criteria for different elevation ranges were selected somewhat empirically. Moreover, no Southern African areas were considered in the process of determining these values. Mountains are not just "invisible" as alluded to in the introduction with respect to policy, but also "elastic."

We finally selected the criteria of a lower critical elevation of 850 m, a slope gradient of 5° and an elevation range of 300 m over 7 cells as a basis for our definition of mountains. This is referred to as "mt850/5/300." It is reassuring to note that this definition generates approximately the same proportion of mountain area as that used by Rabie et al (1994). It is also worth noting that excluding the lowest class of the WCMC classification (300 m to 1000 m, with most of it below our lower critical elevation of 850 m) in the Debarbieux et al (2000) calculations reduces the mountainous area for South Africa to 16.58%.

Definition of mountains based upon proxy variables

Two proxy alternatives to using topography were explored, the first using vegetation and the second drawing upon linguistic (ie, cultural) characteristics of place names.

Using vegetation as a proxy variable for topography

Kapos et al (2000) suggest that high resolution vegetation data would help to improve the accuracy of a mountain definition at subnational scales, and that the geographical distribution of plant communities characteristic of mountains could therefore be a good proxy for the distribution of mountains. The biogeography of Southern Africa contains sets of species that are specifically adapted to mountain areas. We used data from a study on regional vegetation by Low and Rebelo (1996), and digitized data available from ENPAT. These were digitized from paper maps at various scales ranging between 1:125,000 and 1:100,000. We identified the rows in the attribute database for which the topographic descriptions implied non-lowland areas, and then identified the corresponding vegetation types for those same records. This mountain biome model identifies 13.8% and 11.4% of Southern and South Africa, respectively, as mountainous. Of the 7 biomes present in Southern Africa, only the 3 noted in Figure 2 were identified as being present in non-lowland areas. Low and Rebelo (1996) provide detailed regional tables of plant communities for each biome within Southern Africa.

Each vegetation type is assigned to a broad biome classification where grouping is based upon common species and vegetation structure. However, some subgroups within the biota, such as *mountain fynbos*, are themselves classified according to elevation characteristics, thereby creating a degree of circularity. Consequently, although the vegetation mapping provides a useful check on the distributions it does not in itself offer a practical solution.

Figure 2 illustrates that the geographical extent of mountains as defined by mountain biomes has some similarity with the mountain area defined by the mt850/5/300 model, but the main massifs and scarplands are more pronounced, and much of the terrain in the Natal Midlands zone is excluded.

Comparing the vegetation and topographic models: We calculated the area of overlap between the areas designated as mountainous by the mt850/5/300 and mountain biome models to be only 4.6% of Southern Africa. In relation to the respective areas classified as mountains, the intersection accounts for only 33% of mountain biome and 47% of mt850/5/300. However, these relatively low values should be interpreted with caution. The mountain biome model uses the vector model, while mt850/5/300 was derived from raster data. The boundaries for the vector data are illustrative at the regional scale and do not identify any micro variations. The raster data, operating at intervals of approximately 1 km, do pick out micro variations. Consequently, the locations where both layers coincide are considerably underestimated. These observations illustrate the dangers of drawing erroneous conclusions from analysis when the characteristics of the data used are not sufficiently appreciated.

For convenience, the quantitative results from mountain definitions suggested by different authors and the results from our own approaches are summarized in Table 1. In the following section, the cultural model is presented. As it is not expressed in areal terms, it is not referred to in Table 1. Subsequent sections will indicate that the socioeconomic consequences are relatively constant, despite such wide variations in definitions.

Using cultural characteristics as a proxy variable for topography

So far, the study has approached the problem of identifying mountain regions by using relatively precise Euclidian geometric concepts. A more culture-orientated model can be constructed through the interpretation and plotting of place names. It must be stressed that unlike the previous analyses, this one only considered data for South (as opposed to Southern) Africa. A 10% sample of mountain names was derived from the Defense Mapping Agency's (1992) gazetteer of South Africa's place names. The gazetteer has been produced from a wide range of authoritative sources and records approximately 118,700 place names, each one categorized by the United States Board on Geographic Names into a standardized designation. The 3 designations of particular interest to this study are "mountain," "mountain range" and "highland." Mountains are defined as landforms displaying "conspicuous" relief with moderate to high elevation and a discernible, small summit area. Highlands are defined as extensive landform regions exhibiting a mixture of mountains, hills and plateaus. The analysis used a systematic sample of mountain names, as this combined operational ease with lack of bias. The latitude and longitude of each sampled place was recorded and imported into the GIS (Figure 3).

The 10% sample produced 629 place names, of which 580 referred to mountains and 49 to mountain ranges. The sample did not select any highland names. Although it would be unwise to assign areal units with this method, Figure 3 suggests a broad correlation between the mt850/5/300 distribution and that based upon this selection of place names. The place names are more widely distributed than the compact areas resulting from the topographic model, reflecting the use of these terms in lower, dissected areas. Some of the outliers are clearly local prominent points where the relative relief creates a mountain-like feature. This approach seems promising for further research.

TABLE 1 Mountain areas according to the various definitions discussed in this article. The "cultural" definition is not included as it is not expressed in areal terms.

Previous definitions	Mountain area in Southern Africa (% of total territory)	Mountain area in South Africa (% of total territory)
Debarbieux et al 2000	31.4	29.4
Kruger 1983	20.5	20.9
Rabie et al 1994	–	10
New definitions presented in this article		
mt850/5/300 model	9.8	8.3
Mountain biome model	13.8	11.4
Overlap from mt850/5/300 and mountain biome models	4.6	3.2

Mountain population in South Africa

There have been a number of significant contributions on the use of GIS in mountain areas that concentrate particularly on issues arising from problematic data (Price and Heywood 1994) and, more recently, discussions surrounding the need to generate data for both environmental and social policy. An example of the latter is the FAO working paper by Huddleston et al (2003), which refers to demographic and poverty issues.

FIGURE 3 Distribution of a 10% sample of mountain-designated place names superimposed on the mt850/5/300 model (see also Figure 1). (Map by authors)

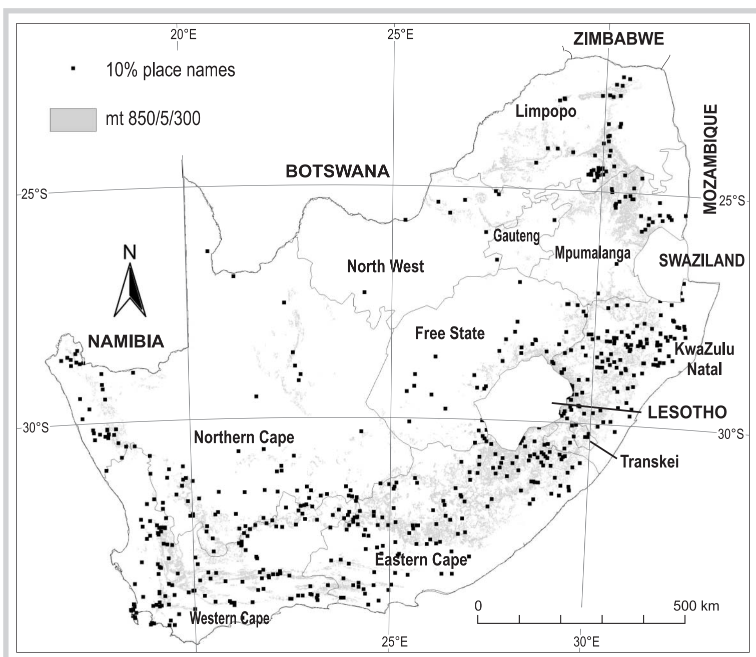
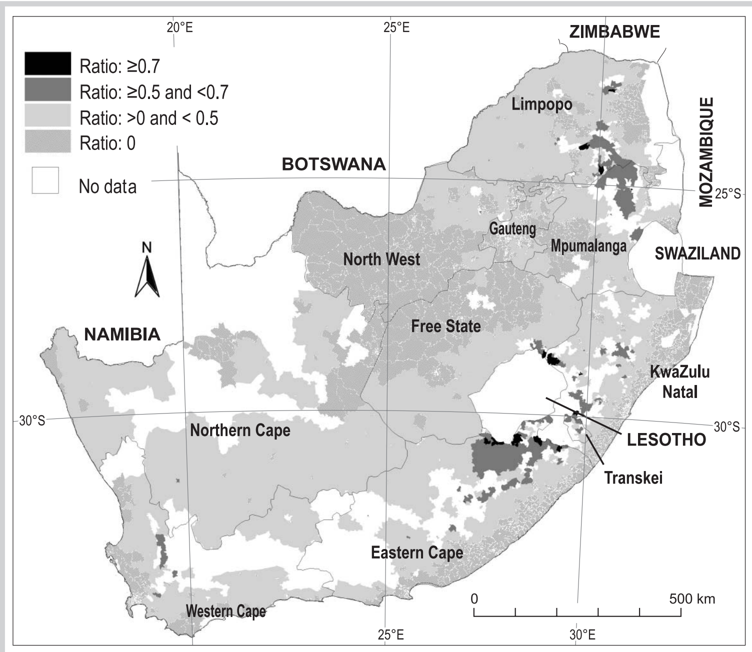


FIGURE 4 Distribution of wards classified as mountainous according to the mt850/5/300 model, with different ratios (see also Figure 1). (Map by authors)



From a policy perspective, attempting to define mountains has little relevance unless it is used to gain a deeper understanding of the population characteristics and economic activity within an area. For South Africa, the Municipal Demarcation Board (2000) produces digital administrative ward boundary data existing at the time of the 1996 census (ward data for 2001 are not yet available). Although a few thinly populated areas are omitted using these data, the total population is only reduced by 0.68% when compared with the population data for municipal areas, ie, the next highest administrative framework for which full national coverage is available.

Administrative areas rarely correspond to ecological or topographic zones. Nevertheless it is possible to calculate the number of cells classified as mountain which fall within a given ward. Whether that ward is labeled "mountain" will depend on a predetermined proportion of the cells in the ward being "mountain." We can choose how stringent we wish to be by setting a ratio (eg, 0.5 or 0.7). Therefore, if for example 50% of a ward (ie, a ratio of 0.5) is classified as mountainous according to the mt850/3/500 model, then operationally, the entire ward is considered mountainous. There are 3745 wards with a relatively low mean size of 261 km^2, so overall the approach provides a reasonable approximation of reality. Figure 4 illustrates the distribution of wards classified as mountainous using this methodology, with Province boundaries shown for reference. The blank areas include Lesotho, Swaziland, as well as the thinly populated areas noted earlier.

Table 2 shows the relationship between the critical ratio of total area to mountain area within a ward used to define "mountain ward," and the resulting total mountain population. Confining our analysis to wards with a ratio of at least 0.5, the result is a mountain population of 1,206,831 or only 3% of the total 1996 population. Using the ratio of 0.7, the mountain population falls to 0.34% of the total 1996 population. As is to be expected, given our more stringent definition of mountain areas, these figures are much lower than the estimates provided by Huddleston et al (2003), which are based on the WCMC classification. However it is worth noting that while population density in mountain areas increases as the ratio changes from 0.3 to 0.7, non-mountain population density virtually stays the same.

Socioeconomic characteristics of mountain areas in South Africa

A critical question addressed by Huddleston et al (2003) concerns the scale and spatial extent of poverty in mountainous areas. Kreutzmann (2001) attempts to develop socioeconomic indicators for mountain population. For this paper we have followed Lipton and Ravallion (1995), who describe poverty as the condition where "one or more persons fall short of a level of economic welfare deemed to constitute a reasonable minimum, either in some absolute sense or by the standards of a specific society." Different ways of arriving at poverty measures are now the focus of extensive discussions (Ravallion 1992; Klasen 1997). Based on the available

TABLE 2 Mountain population figures for South Africa resulting from the use of different ward-area-to-mountain-area ratios.

Ratio of total ward area to mountain area	Total population in "mountain wards"	Mountain population (% of total national population)	Number of "mountain wards"	Density of mountain population (km^2)	Density of non-mountain population (km^2)
Ratio: ≥ 0.3	3,293,786	8.12	354	34.19	42.04
Ratio: ≥ 0.5	1,206,831	3.0	127	37.03	41.42
Ratio: ≥ 0.7	138,257	0.34	16	54.95	41.23

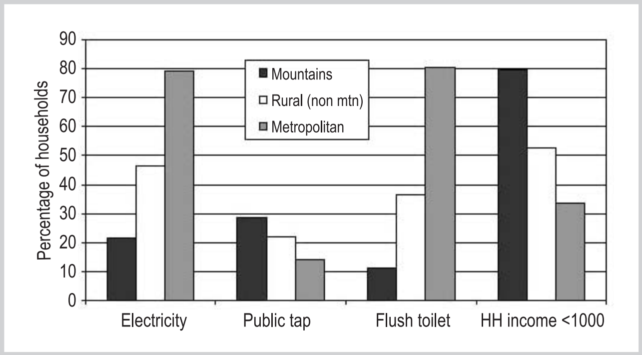


FIGURE 5 Poverty indicators in South Africa. (Source: Municipal Demarcation Board 2000)

data we have chosen 2 approaches, one using a poverty datum line defined by a household subsistence level, and the other using a group of assets: access to flush toilet, public tap and networked electricity. A number of studies have suggested that in the mid 1990s the household subsistence level was approximately ZAR 1000 (US$ 155) per month per household (Klasen 1997; May 1998).

Using the mountain zone defined by the 0.5 ratio criterion, Figure 5 shows the proportion of households which either do not have access to one of the 3 utilities or fail to meet the prescribed household income level. The data are divided into 3 distinct zones: mountain, rural non-mountain, and metropolitan. In 1996 the population for the metropolitan zone was 12 million persons, which is a reasonable approximation even though it does not include all urban areas, owing to incomplete data.

Unsurprisingly, for all 4 variables there is an observable, and in 3 cases a marked difference between the metropolitan areas and elsewhere. But of even greater importance from a policy viewpoint is the fact that there are marked differences between mountains and other rural areas. Very similar patterns appear for the mountain population defined using a ratio of mountain area to ward area of 0.3 and 0.7, respectively. This suggests that the "elasticity" of mountain definitions does not fundamentally influence associated socioeconomic analysis. The precise level of these figures will alter as the poverty datum line moves, but the differentiation remains similar. Note that access to water via a public tap supply would be much less prevalent in metropolitan areas, where a far greater proportion of households have access to piped water.

Conclusion

The paper began by claiming that mountains in South Africa are "invisible" because they do not appear as a particular ecological feature in many current policy documents in South Africa. This is in marked contrast to the high profile of mountains in the development initiatives of other countries, including countries with apparently limited mountain zones (Funnell and Parish 2001). Using a variety of sources and employing a range of GIS techniques the study has shown that in a conservative estimate, mountain areas occupy approximately 10% of Southern Africa and a just slightly smaller portion of South Africa. The different approaches used have highlighted the highly subjective nature of the decision to assign the term "mountain" to a particular elevation/relief category. The sensitivity of the resultant mountain area suggests that it would be appropriate to use the term "elastic" to describe mountain coverage.

Of greater applied importance is the attempt to answer the question of whether mountainous areas have distinctive socioeconomic characteristics, especially with respect to poverty indicators. We have demonstrated that in South Africa such a distinctiveness exists. Furthermore, it has been shown that socioeconomic conclusions remain relatively constant even though the population numbers will vary according to how a mountainous area is defined. Therefore, although definitions of mountains may be "elastic," the socioeconomic characteristics of such areas are relatively constant.

It is a recognized fact that mountains in the region play a major role in water provision and biodiversity. The mountains are inhabited only by a small proportion of the total population. Nevertheless, this population is undoubtedly poorer than the inhabitants of most other areas. Any policies that interfere with the livelihoods of mountain populations could thus have a significant political impact.

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REFERENCES

Blignaut P, Blignaut J, editors. 1999. *Africa Mountain Protected Areas Update No 3.* Africa Mountain Protected Areas Network. World Commission on Protected Areas/IUCN. Mountain Forum On-Line Library and Reference Database: http://www.mtnforum.org/resources/library/bligx99a.htm; accessed on 25 November 2003.

Debarbieux B, Delannoy JJ, Dobremez JF. 2000. *Les pays du monde et leurs montagnes.* Grenoble, France: Éditions Revue de Géographie Alpine.

Defense Mapping Agency. 1992. *Gazetteer of South Africa.* Volumes I–IV. Fairfax, VI: United States Board of Geographic Names. Also available at: United States Geographical Survey [USGS]. *Geographic Names Information System (GNIS)*. http://geonames.usgs.gov; accessed on 25 November 2003.

Funnell DC, Parish R. 2001. *Mountain Environments and Communities.* London, UK: Routledge.

Government of South Africa. 2001. *Wise Land Use. White Paper on Planning and Land Use Management.* Ministry of Agriculture and Land Affairs. http://www.gov.za/whitepaper/2001/spatialplanning.htm; accessed on 25 November 2003.

Huddleston B, Atamane de Salvo P, Zanetti M, Bloise M, Bel J, Franceschini G. 2003. *Towards a GIS-based Analysis of Mountain Environments and Populations.* Environment and Natural Resources Working Paper No 10. Rome, Italy: Food and Agriculture Organization of the United Nations [FAO].

Kapos V, Rhind J, Edwards M, Ravilious C, Price MF. 2000. Developing a map of the world's mountain forests. *In:* Price MF, Butt N, editors. *Forests in Sustainable Mountain Development. A State-of-Knowledge Report for 2000*. Wallingford, UK: CAB International, pp 4–9.

Klasen S. 1997. Poverty, inequality and deprivation in South Africa: An analysis of the 1993 SALDRU [South African Labour and Development Research Unit] survey. *Social Indicators Research* 41:51–94.

Kreutzmann H. 2001. Development indicators for mountain regions. *Mountain Research and Development* 21(2):132–139.

Kruger GP. 1983. *Terrain Morphology of Southern Africa.* Pretoria, South Africa: Department of Agriculture, Soil and Irrigation Research Institute.

Lipton M, Ravallion M. 1995. Poverty and policy. *In:* Behrman J, Srinivasan TN, editors. *Handbook of Development Economics.* Vol 3B. Amsterdam, The Netherlands: Elsevier, pp 2551–2657.

Low AB, Rebelo AG, editors. 1996. *Vegetation of South Africa, Lesotho and Swaziland*. Pretoria, South Africa: Department of Environmental Affairs and Tourism [DEAT].

May J, editor. 1998. *Poverty and Inequality in South Africa.* Final Report prepared for the Office of Executive Deputy President and the Interministerial Committee for Poverty and Inequality. Pretoria, South Africa. Available at http://www.gov.za/reports/1998/poverty/; accessed on 25 November 2003.

Meybeck M, Green P, Vorosmarty C. 2001. A new typology for mountains and other relief classes: An application to global continental water resources and population distribution. *Mountain Research and Development* 21:34–45.

Municipal Demarcation Board. 2000. *SA Explorer*. CD v1.0. Hatfield, South Africa: Municipal Demarcation Board. Also available at: http://www.saexplorer.org.za/; accessed on 25 November 2003.

Price MF, Heywood DI, editors. 1994. *Mountain Environments and Geographic Information Systems.* London, UK: Taylor & Francis.

Rabie MA, Blignaut PE, Fatti LP. 1994. Mountains. *In:* Fuggle RF, Rabie MA, editors. *Environmental Management in South Africa*. Cape Town, South Africa: Juta.

Ravallion M. 1992. *Poverty Comparisons: A Guide to Concepts and Methods.* Living Standards Measurement Study [LSMS] Working Paper No 88. Washington, DC: World Bank.

Schulze RE. 1997. *South African Atlas of Agrohydrology and Climatology.* Water Research Commission Report TT82/96. Pretoria, South Africa: Water Research Commission.

Short NM. 2003. Terrains in TM imagery: Ridges and elevations. *The Remote Sensing Tutorial.* Center for Airborne Remote Sensing and Technology and Applications Development [CARSTAD]. http://rst.gsfc.nasa.gov/Sect17/Sect17_8.html; accessed in November 2003.

USGS [United States Geological Survey]. 2003. *GTOPO30 Documentation.* Land Processes Distributed Active Archive Center. http://edcdaac.usgs.gov/gtopo30/README.html; accessed in November 2003.