# Bridging the divide between intuitive social-ecological value and sustainability in the Manica Highlands of southern Africa (Zimbabwe-Mozambique)

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**Abstract**

Southern African mountains remain poorly studied as social-ecological systems (SES) and are poorly represented in the global mountain discourse. However, these mountains provide essential ecosystem services (ES) that underpin local and regional development. Quantitative data on ES, their representation in policy, and the political will for sustainable management are limited. We demonstrate this using the Manica Highlands (MH; Zimbabwe—Mozambique): benefiting one million immediate and five million downstream beneficiaries, the seven identified ES are supported in the literature but lack recent quantitative data needed to persuade policymakers for action to promote sustainability. The ES are most at risk from mining, alien invasive species, rapid land transformation, and climate change – yet fine-scale quantitative data to inform mountain-specific policy on these are also lacking. We recommend a 'science to policy to action' agenda for the MH, but highlight that the greatest challenge to achieving sustainability is a lack of effective governance; therefore it may be difficult to change 'immediate benefits'-thinking to higher ideals that would render the ES of the MH sustainable. As a result, academics, civic society, policy makers and governance instruments should work closely together to quantify the value of the MH, and to formulate specific policy for the MH.

**Highlights**

- The Manica Highlands provide seven recognized ecological services.
- There are one million immediate and five million downstream beneficiaries.
- There are four main threats to the ecological services.
- There is no specific policy for ensuring the sustainability of these ecological services.
- Effective governance remains the most elusive hurdle to achieving sustainability.

**Key words**

Ecosystem services; mountains; southern Africa; Manica Highlands; Zimbabwe; Mozambique.

## 1. Introduction

### *1.1. Africa's mountains provide valuable ecosystem services*

Mountains (including uplands, highlands and escarpments, as defined by Körner et al., 2011) provide unique ecosystem services (ES) essential to social and economic development in both rich and poor countries (Körner et al., 2005; Viviroli et al., 2007; United Nations (UN) General Assembly, 2014; Kohler and Maselli 2009; Grêt-Regamey et al., 2012; Ariza et al., 2013; Kokkoris et al., 2018; Klein et al., 2019; Vannier et al., 2019). As the world's second-driest continent, mountain ecosystems in Africa are particularly important. For example all economically and socially important major rivers in Africa have their sources in mountains. African mountains also provide an environment on which more than 28 million people directly rely for their livelihoods (Kohler and Maselli, 2009; United Nations Environment Programme (UNEP), 2012, 2014). In addition, Viviroli et al. (2003) indicate that in arid regions, mountains provide as much as seven times more runoff than lowlands and contribute up to 90% to the total runoff in a river basin. In semi-arid South Africa, for example, only 8% of the nation's surface area (mostly the mountains and highlands) provides 50% of the country's fresh water resources (World Wildlife Fund (WWF), 2013), and southern Africa is an area characterised by high levels of water insecurity (Southern African Development Community (SADC), 2011). This is because sub-tropical regions such as southern Africa, with high rainfall seasonality and unpredictability, are even more reliant on ecologically intact mountain catchments as a stable source of water supply (Kohler and Maselli, 2009).

### *1.2. Southern Africa's mountains are poorly understood social-ecological entities*

Only 22% of Africa exceeds 1000 m above sea level (asl) (Artyushkov and Hofmann, 1998) while only 5% exceeds 1500 m, and most of this is in eastern and southern Africa (UNEP, 2014). Eastern Africa is here defined as occurring east of the Congo Rainforest, north of Lake Rukwa, and south of the Red Sea Hills; southern Africa is defined as occurring south of the Congo Rainforest and Lake Rukwa. Of the two regions, eastern Africa has had the lion's share of research attention. This is evident in international research interest, NGO attention, and that most publications relating to African mountains (including UNEP's, 2014, *Africa Mountains Atlas*) are more detailed about eastern African mountains than their southern African equivalents. Southern African mountains, for instance, are poorly represented in the *Atlas*, and several of the statements relating to them are inaccurate. This is further emphasised in the *African Mountains Status Report* (Alweny et al., 2014), which provides somewhat inaccurate and only sketchy details about southern Africa's mountains. It is obvious that the authors of these reports had little contact with southern African mountain researchers.

Southern Africa's limited presence in the global mountain research forum is re-emphasised in the recent work of Klein et al. (2019) on global "mountain social ‑ ecological systems", which uses only one southern African case study site, while the remainder of African case study sites – except for two in northern Africa – are in eastern

Africa; in contrast, 37 of the total 57 are in the northern hemisphere. Reasons for limited southern African participation could include South Africa's continued sense of psychological isolation from the rest of Africa as a legacy of Apartheid; Zimbabwe's economic and political problems since 2000; (prior) extended civil war in countries such as Mozambique and Angola; post-war limited accessibility due to lack of infrastructure; and language barriers with Anglophone African researchers. In addition, southern African mountain research has been a small component of regional research, and the full-time mountain-focused 'community of practice' is small. There is also a lack of co-operation and research cross-pollination between African researchers, so that several African mountain network organisations with their own separate memberships exist. In addition, a large proportion of research on African mountains is driven by organisations based outside Africa, particularly in Europe and North America.

As a result, the montane social-ecological systems in eastern Africa are much better understood than those in southern Africa. This often results in an imposition of eastern African ecological knowledge on mountains in southern Africa – for example, a disproportionate focus on montane forests and the assumption that montane grasslands in southern Africa are anthropogenic landscapes resulting from millennia of deforestation and the overuse of fire (e.g. White 1978, 1981).

In contrast to the high altitude, iconic eastern African mountains, most southern African mountains consist of either comparatively gentle highlands and uplands or large inselbergs, or form part of the southern African Great Escarpment as the impressive edge to an otherwise relatively featureless and extensive inland plateau (Moore et al., 2009). This is due to the predominance of ancient lithologies and erosional orogeneses in southern African mountains compared to active rifting and associated younger volcanics in eastern Africa (Schlüter, 1997). Also, perhaps due to their often lack of dramatic character, assumed difficulty to access for research, as well as savannah-focused tourism industries, southern African mountains are overall the most poorly researched mountains on the continent. While piecemeal research has been done in various localities of the Maloti-Drakensberg (the highest and most dramatic of southern African mountains), most other montane systems have hardly been explored in most disciplines (for example, see Clark et al., 2011, for a review on the Great Escarpment, including the Maloti-Drakensberg). This is unfortunate as southern Africa hosts the largest network of upland areas in Africa, as well as some of the poorest countries in Africa; mountain-generated ES therefore offer potential for sustainable economic development and poverty alleviation in these countries, if stewarded wisely.

*1.3. Southern Africa's mountains require inter-disciplinary research on ecosystems services*

Valuation of ES as a concept was first highlighted by Westman (1977) as a means to explicitly value, in monetary terms, items in nature that were formerly regarded as difficult to put conventional financial value on. Since then the research field of environmental economics has been well established (see Brauman et al., 2007; Balmford et al., 2008; Yoe et al., 2009; Bullock et al., 2011; van der Horst, 2011; Blignaut et al., 2012; Burke et al., 2015 – and with dedicated journals, such as the Journal of Environmental Economics and Management), where ES valuation has been developed as a vehicle to integrate ecological understanding and economic considerations to redress the traditional neglect of the value of ES in policy decisions (de Groot et al., 2002; Chee, 2004). The trend towards valuation persists, often as a means to justify the allocation of funds for ecosystem maintenance and restoration in a highly competitive funding world (Van Wilgen et al., 1996). But there is still controversy over the use of valuation, with many authors unconvinced of its real value in terms of sustainable use and conservation (see Farber et al., 2002; Small et al., 2017).

However it is increasingly recognised that one of the methods to bridge the gap between policy and the long term sustainability of ecosystems is through economic quantification of ES, if it can be demonstrated that these ecosystems are intimately linked to long-term human wellbeing (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), 2010; World Bank Group, 2012, 2015a). Consequently, there is a need for scientifically robust research into ES that can translate into effective policy and management, especially in poor countries (Carpenter et al., 2006; Holdren, 2008; Fisher et al., 2011b). Also, there is need for promoting use of simple valuation tools that can be used to collect basic scientific data through citizen science (e.g. Toolkit for Ecosystem Services Site-based Assessment, TESSA). In many poor countries, economic motivation may be the only means of creating interest and impetus to address major risks to ES.

There are numerous examples relating to the economic valuation of mountain-derived ES (Navraj et al., 2010; Kokkoris et al., 2018). The montane ecological processes that supply these ES are typically under threat from detrimental land-uses, unsustainable use of natural resources, invasive alien species (IAS), climate change and governance issues (Holdren, 2008; Fisher et al., 2011b; Klein et al., 2019). These challenges require a more careful examination of mountain environments by local and regional policy makers (Klein et al., 2019), with an emphasis on long term sustainability and adaptability to ensure that montane ES are provided in perpetuity (Kokkoris et al., 2018; Klein et al., 2019). The most comprehensive recent example in an African mountain context is the *Valuing the Arc* project, which ran from 2007 to 2012 in the Eastern Arc Mountains of Tanzania in eastern Africa (Fisher et al., 2011a, b; Burgess et al., 2014). The project assessed the value of water, carbon sequestration, biodiversity, non-timber forest products (NTFP), indigenous hardwood timber, and tourism in the 520,000 km$^2$ Eastern Arc Mountains (Fisher et al., 2011a, b; Bayliss et al., 2014; Burgess et al., 2007, 2014; Schaafsma et al., 2012, 2014a, b). The results showed that: (1) the Eastern Arc Mountains water supplied 20% of Tanzania's population, produced 60% of Tanzania's electricity and supported 80% of Tanzania's industry; (2) 170 animal and 609 plant taxa were endemic to the Eastern Arc Mountains; (3) indigenous forests stored 6.33 billion metric tonnes of carbon in the year 2000, equalling US$519 billion and 80% of human-related $CO_2$ emissions that year; (4) nature-based tourism generated some US$195,000 per annum; and (5) non-timber forest products generated US$42 million per annum. There was also a focus on the potential impacts of climate change on local endemism and biodiversity, with changes in moisture regime being the most important determining factor (Platts et al., 2013). The research approach was orientated to developing policy-ready outputs that could be used by the Tanzanian state to inform decisions and future actions (Fisher et al., 2011b; Lopa et al., 2012; Burgess et al., 2014). The topic has also been somewhat explored in South Africa (Higgins et al., 1997; Milton et al., 2003; Mullins et al., 2007; Blignaut et al., 2008, 2010, 2012; Mander et al., 2010; Snyman and Jewitt, 2010; Quayle and Pringle, 2014; Turpie et al., 2017), which relies heavily on its mountainous regions (and those in Lesotho) for its water (Turpie et al., 2008; van Zyl, 2009; Crookes, 2012), although not in a comprehensive manner as does the Eastern Arc Mountains in terms of holistic orographic and ES focus.

Given that no mountain range in southern Africa has been comprehensively studied for the purposes of valuing ES, assessing threats or making policy recommendations, we take a discrete, poorly-researched mountain range in southern Africa – the Manica Highlands (MH), on the border between Zimbabwe and Mozambique – to review the state of knowledge regarding ES and their threats, and provide recommendations for research and policy implementation.

*1.4. The Manica Highlands of Zimbabwe–Mozambique*

The Manica Highlands (MH) form a natural boundary between Zimbabwe and Mozambique, being 300 km long in a north-south alignment and covering 8200 $km^2$. The MH is shared approximately equally between the two countries with the majority of the Nyanga massif being in Zimbabwe and the majority of the Chimanimani mountains in Mozambique. Although not a large montane system (the UNEP (2014) *Africa Mountains Atlas* only mentions the MH in transient references in figures and maps) or high (maximum altitude 2593 m: Mt Nyangani), the MH represent a microcosm of the research opportunities and sustainable development challenges facing moist mountain systems in southern Africa.

Based on natural topography, the MH can be divided into four distinct sections (Figure 1; and see Moore et al., 2017):

(1) Nyanga in the north, comprised of extensive grassland plateaux, indigenous forests, archaeological/cultural sites, commercial forestry and extensive feral woody invasion. The most detailed review of Nyanga is provided by Clark et al. (2017);

(2) The middle-altitude Stapleford-Penhalonga-Bvumba area in the centre, comprising a mosaic of indigenous forest, commercial plantations, various forms of agriculture, mining, remnant natural grassland, and a variety of middle-income to upmarket properties in the Bvumba, which is a popular mountain retreat area;

(3) A southern section, ranging from the relatively high Tsetserra–Himalaya area in the north (grasslands and indigenous forests), through extensive areas of intense commercial forestry and rural subsistence agriculture in the centre, to the moderately low-altitude Chirinda rainforest in the south (the latter addressed in detail by Timberlake and Shaw, 1994);

(4) The Chimanimani mountains, comprising the most rugged, mountainous and wilderness part of the MH, and hosting the highest levels of local endemism (Wursten et al., 2017).

To date, although it is intuitively known by the academic community that the MH is a provider of unique ES to Zimbabwe and Mozambique, these ES have not been quantified or valued with the intention of encouraging policies to support sustainable development, poverty alleviation, resuscitation of previously high job-creating and income-generating local industries (tourism, commercial farming, forestry), biodiversity conservation or improved international co-operation. This was further emphasised in 2017 by a proposal from the Zimbabwean Ministry of Mines and Mining Development to de-proclaim 10000 $km^2$ of protected area in Zimbabwe for artisanal mining (including Chimanimani National Park), and subsequent lobbying by environmental non-governmental organisations (NGOs) and Traditional Authorities with the Ministry, highlighting a lack of appreciation by the Zimbabwean and Mozambican governments of the montane ecosystems in the Manica Highlands and the social-economic value they provide (especially directly to local people). This is because (1) the ES have never been rigorously quantified, so data are limited, (2) threats to these ES have not been quantitatively assessed, and (3) traditionally the MH has not formed a strong component of the national policy-psyche in either country. Due to

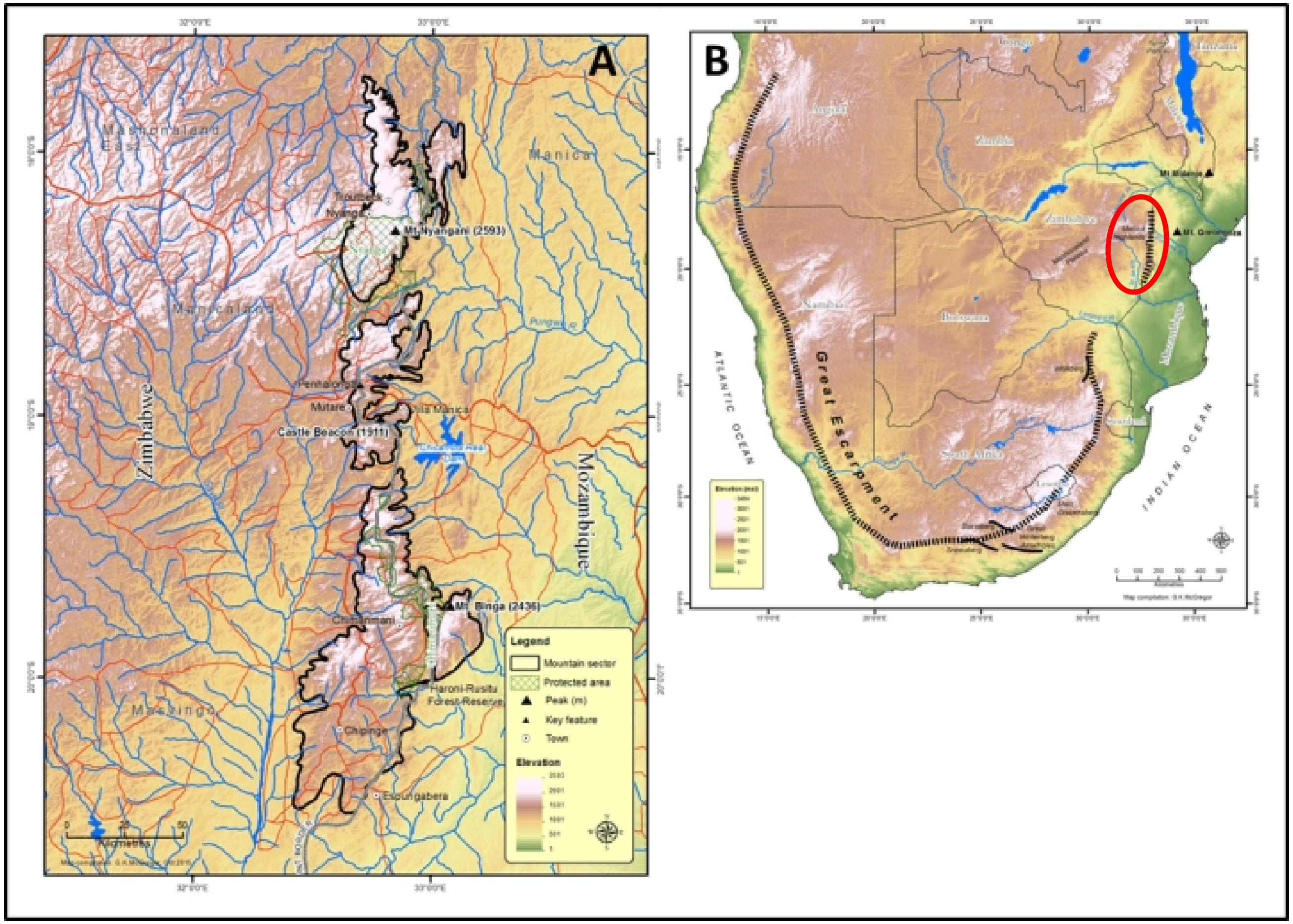


***Figure 1: (A) The Manica Highlands, Zimbabwe–Mozambique, and (B) their position in south-eastern tropical Africa. (from Clark et al. 2017, with permission from the Editors and Publisher of Kirkia).***

the lack of data, the case for maintaining and improving natural capital in the MH currently presents a weak argument compared to that of an immediate-benefit, non-renewable resource focus, such as mining. Integrating natural capital into decision-making processes is an under-explored concept in both countries (BirdLife Zimbabwe, 2012).

## 2. Materials and Methods

The applicability of the ES examined by the *Valuing the Arc* project (water production, carbon sequestration, biodiversity, NTFP, indigenous hardwood timber, and tourism; Fisher et al., 2011a, b; Burgess et al., 2014) were taken as the basis for this review of ES in the MH. From available knowledge, the most obviously applicable ES were identified as water production, carbon sequestration, biodiversity, and tourism (the 'big four'). 'Non-timber forest products' is a broad category, and we have considered a variety of aspects under this concept. Indigenous hardwood timber has been excluded as a ES as Shumba (2001) indicates that there is very little commercial value in the MH, in contrast to the predominance of valuable gymnosperm-dominated (*Podocarpus* and *Widdringtonia*) montane forests in South Africa and Malawi. The valuable hardwoods in Zimbabwe and Mozambique are savannah species predominating in western Zimbabwe, and elsewhere than the MH in Mozambique. We have added two ES that were not included in the *Valuing the Arc* project, due to the different ecological nature of the MH compared to the Eastern Arc Mountains: (1) a montane climate and montane grassland suitable for extensive commercial forestry (non-native timber) and other predominantly montane agricultural activities, including natural rangeland (montane grassland) for the grazing of livestock; and (2) historical, cultural and spiritual value (although these could be included under 'tourism' we felt that they are distinct enough for their own category).

A review of the main ES in the MH would not be complete without a companion review of the main threats to the sustainability of these ES, as policy would need to inform action against these threats. As the MH forms part of the Eastern Afromontane Biodiversity Hotspot (Küper et al., 2004; Critical Ecosystem Partnership Fund (CEPF), 2012), two obvious threats cited for the Hotspot were taken as a starting point, namely unsustainable land-use pressure (which we have renamed land-use change) and climate change. We supplemented these two threats (from our local knowledge of the MH) with (1) IAS and (2) mining.

Literature review was used to gather as much information on the MH as possible on the selected ES and the identified threats. Extensive use of the internet was made, using 'Zimbabwe', 'Mozambique', the selected ES and threats as the main search terms; non-digital and difficult to access information was shared by members of the Manica Highlands Initiative (MHI; currently a network of c.100 academics, conservationists, citizen scientists, community members, NGOs and government officials in Zimbabwe, Mozambique and elsewhere); hard-copy literature unavailable online was included as encountered. The overall paucity of peer-reviewed literature relating specifically to most ES in the MH context means that this paper leans heavily on unpublished data, policy briefs, grey literature, company reports, newspaper articles, personal communications, non-peer reviewed books, popular articles and personal observations by and experiences of the authors (VRC, IMG, TF and SLC). We are aware that there may be (e.g. hard-copy) data overlooked through digital inaccessibility and the need to physically visit government offices to access archives. This highlights the need for a dedicated and rigorous research investigation of ES in the MH context.

## 3. Results and Discussion

### *3.1. Social-Ecological value*

Approximately one million people live in the MH and are directly dependent on its ES, while downstream beneficiaries of the MH's ES could number from 2.2 to five million people, based on estimates from BirdLife Zimbabwe's extensive community engagement activities in the area and from census data for urban areas available on Wikipedia.

#### *3.1.1. Water Production*

The MH is one of the few places in Zimbabwe and Mozambique which supports perennial streamflow with associated benefits for domestic use, agriculture and hydropower (Davis and Hirji, 2014; Government of Mozambique, 2014). One of the most important rivers emanating from the MH is the Pungwe, its source being Mount Nyangani (Zimbabwe), and which discharges into the Indian Ocean near the city of Beira (Mozambique). Along its 400 km course, it supports a variety of livelihoods including tourism/recreation (Nyanga and Gorongosa National Parks), and irrigation for both commercial and subsistence farming (van der Zaag, 2000). The Pungwe provides potable water for approximately 350,000 urban residents in immediate proximity to the MH (including one water transfer scheme to the town of Mutare) and downstream to the city of Beira (population 500,000). Although the montane portion of the catchment is only 5% of the whole, the high rainfall in the MH contributes a substantial amount to total river flow (van der Zaag, 2000; Governments of Mozambique and Zimbabwe, 2006). Demand on the river is anticipated to grow, causing severe shortages by 2025 (Governments of Mozambique and Zimbabwe, 2006). Beira's water intake facilities – situated near the estuary – are already subject to contamination by salt water at spring tides and low-flow periods, and it is projected that any increase in upstream abstraction may exacerbate this (Swedish International Development Cooperation Agency (SIDA) and Cap-Net, 2008). A decrease in river flow may be compounded by increasing loss of groundwater supply in the upper catchment from high water-use commercial forestry (projected to grow by 5% between 2008 and 2025) and densification of woody IAS (van der Zaag, 2000; Calder and Dye, 2001; SIDA and Cap-Net 2008). This indirect water usage is estimated at 31 million $m^3$ per annum (Government of Mozambique et al., 2004). A drop in discharge quantity in the Pungwe River will also cause severe problems for far-downstream irrigation schemes such as the Mafambisse Sugar Estate (van der Zaag, 2000). Although both countries have committed to using water resources in a way that reduces poverty and encourages economic development (Governments of Mozambique and Zimbabwe, 2006), there is overall limited data available on water production of individual catchments in the MH (e.g. the Biriri, Haroni, Musapa, Nyahode, Nyanyadzi, Odzi, Rusitu, Umvumvumvu Rivers, etc.) and their socio-economic value.

Africa has vast untapped hydro-power potential, and harnessing hydro-power may become the domain of independent power producers rather than parastatals in the form of numerous, dispersed small plants (<10 Kw to 10 MW; van der Wat, 2013). However, these projects require a minimum stream flow to operate (Black Crystal Consulting, 2013). Several small hydro-power schemes have been implemented in rivers rising from the MH since the 1960s (Energy Sector Background for Manicaland Province, no date). More recently, given the low levels of electricity access to rural populations (19% in Zimbabwe, 7% in Mozambique), there has been a focus in southern

Africa to harness more hydro-power emanating from mountains to alleviate load on the current grids (Black Crystal Consulting, 2013; Government of Mozambique, 2014). Several new (post-2012) projects have also been proposed, the risk assessments of which include impacts of alien vegetation and commercial forestry on reducing water volumes below the level of economic feasibility (Black Crystal Consulting, 2013). In addition to small hydro-power, the Mavuzi and Chicamba Real Dam hydro-plants (52 MWe and 38,4 MWe respectively; Global Energy Observatory, no date; MacauHub, 2016) in Mozambique rely almost exclusively on water emanating from the Bvumba and Chimanimani sections of the MH. By 2016 the Mozambican government had invested US$120 million in their refurbishment (MacauHub, 2016), and it can reasonably be assumed that electricity generation would be negatively impacted from loss of catchment function in the MH that may cause reduced stream-flow and dam sedimentation.

*3.1.2. Carbon sequestration*

The indigenous montane forests in the MH are likely to provide high carbon sequestration value that has not been considered from an economic perspective. Extensive fieldwork in the 1970s totalled the natural forest in the Zimbabwean portion of the MH at 107 $km^2$ (mostly protected; Müller, 2006). Most of the montane components are in reasonable condition, not having been affected by large-scale deforestation typical of other tropical African mountains due to steep topography. However, the lowland forests on the moister eastern side and in the major valleys running through the MH have largely been cleared, including the Honde Valley and the Haroni-Rusitu Botanical Reserves. A carbon sequestration value for these forests might provide both a rehabilitation and conservation incentive that could be explored in a Payment for Ecosystems Services manner (PES; *sensu* Frost and Bond, 2006), and also applied to adjacent degraded lowland forests. The carbon sequestration value of various savannah woodlands has been shown in other parts of Zimbabwe and Mozambique, often equalling the value of cropland (Campbell and Luckert, 2002; Grace et al., 2010; Harris and Roach, 2013; Leach and Scoones, 2015).

To date in the MH only some commercial forestry plantations have been valued in this regard (Mabugu and Chitika 2002; Mujuru et al., 2014), and although these and feral invasions of woody aliens in the MH could also be considered a valuable form of carbon sequestration, their immediate and long-term detrimental impacts on other important MH ES (notably water and biodiversity) strongly discourage these for consideration as a primary carbon sequestration vehicle. Proposals to promote the conversion of natural montane grasslands in Africa and elsewhere globally to woody invasive species for above-ground carbon sequestration purposes (e.g. REDD+; World Resources Institute, 2014; UN-REDD Programme, 2016; Forest Carbon Partnership Facility, 2017) should be vigorously opposed (Parr et al., 2014; Veldman et al., 2015b). The flawed rationale – i.e. that montane grasslands are degraded vegetation types (Veldman et al., 2015a, b), a misapplied assumption based (for instance) on the local ecology of younger East African mountains like Mount Kilimanjaro (see White, 1981), combined with the assumption that ‘more trees are better’ (Parr et al., 2014) – reflects a lack of understanding of the evolutionary and ecological value and functioning of these mega-biodiverse and irreplaceable ancient montane grasslands (Meadows, 1983; Meadows and Linder, 1993; Veldman et al., 2015a, b; Bond, 2016; Bond and Zoulamis, 2016). Recent synthesis work on plant diversity and endemism in the MH highlights that grassland supports most endemic species in the MH, not forest (Clark et al., 2017; Wursten et al., 2017). Such efforts should rather be focused on the restoration or rehabilitation of degraded woody landscapes in Africa, *inter alia* lowland rainforests, riparian forests, savannah woodlands and mangroves, etc. In the context of the MH this would be most applicable to the lowland and riparian forests on its lower eastern flanks (as indicated above), and *Brachystegia-Uapaca* woodland on its western flanks.

### *3.1.3. Biodiversity*

The biodiversity of the MH represents an important transition in White's (1978, 1981) Afromontane archipelago from tropical to temperate vegetation, and is the only place in Africa where this occurs. This is because the western Escarpment counterpart to the MH – the mountains around Windhoek in Namibia – is too arid to host an Afromontane biota. The result is that the MH are the northern limit for many temperate montane taxa and the southern limit for many tropical montane taxa (Weimarck, 1941). In addition the MH are also a link for many taxa which are widespread throughout the Afromontane region, and have high evolutionary significance as stepping stones (van Wyk and Smith, 2001; Galley et al., 2006, 2007; Gehrke and Linder, 2009). Genetic studies on montane organisms in southern Africa are few, and those that include samples from the MH are even fewer. However, results from limited published and unpublished data indicate that taxa from this region are genetically distinct. This has been found in birds (Bowie et al., 2004), rodents (Castiglia et al., 2012; Taylor et al., 2009; Taylor et al., 2013), butterflies (NPB, unpublished data) and plants (Kadu et al., 2013). These few results indicate that the MH is clearly an important region of unique genetic diversity, and it is highly likely that undescribed cryptic species will be discovered by means of genetic studies.

Floristically, the MH is classified as the Chimanimani–Nyanga Centre of Floristic Endemism (Van Wyk and Smith, 2001). These authors estimated the flora of the MH to be at least 1500 taxa, but current work in progress suggests that it could be double this, with c.250 endemic plants. The highest endemism is in the Chimanimanis mountains (74 taxa; Wursten et al., 2017) followed by Nyanga (23 taxa; Clark et al., 2017), with local nodes of biogeographically anomalous richness and distributions such as Chirinda Forest (Timberlake and Shaw, 1994). The MH supports significant populations of regional but endangered Afromontane plants species, such as *Prunus africana*, a species listed under Appendix II of CITES due to overharvesting as a medicinal plant (Jimu and Ngoroyemoto, 2011).

About 490 bird species have been recorded in the MH, and eight Important Bird Areas (IBAs) have been defined (Childes and Mundy, 2001; Mukwashi and Matsvimbo, 2008). Birds of conservation importance include the endemic Roberts Prinia *Prinia robertsi* and endemic sub-species such as the 'Chimanimani Bokmakierie' *Telephorus zeylonus restrictus*; localised Afromontane near-endemics such as Chirinda Apalis *Apalis chirindensis* and Swynnerton's Robin *Swynertonia swynnertonii*; and birds of regional conservation importance, notably Blue Swallow *Hirundo atrocaerulea*, Taita Falcon *Falco fasciinucha* and Wattled Crane *Cirus carunculatus* (Childes and Mundy, 2001).

Other significant endemism includes c.20 butterflies, c.10 reptiles (some awaiting scientific description), four fish, eight amphibians, eight mammals and numerous Mollusca (unpublished data from W. Cotterill dated 2002, M.W. Gardiner dated 2012, and D. Broadly dated 2013; personal communications with D. and R. Plowes (2013–2016); Martin, no date; Van Bruggen, 1971; Marshall, 2010). Relatively recently, a new crab species was described from Nyanga (Phiri and Daniels, 2013), and a new fish taxon from Nyanga might also be described (Marshall, 2010).

There is much work required by biologists in the MH to fill data gaps, resolve taxonomic problems, and inform conservation policy. Although the MH is fairly well-explored compared to other southern African mountains, there are still areas which are not well documented: consequently new species, range extensions and rediscoveries of 'long lost' species are regular (e.g. Darbyshire and Massingue, 2014; Becker and Hopkins, 2017), even in popular tourist areas (Phiri and Daniels, 2013). Several taxa known to be new for some time still await formal description and publication (van Wyk and Smith, 2001). The population numbers and ecology of many of the endemics are poorly known, and are either listed as Red Data Deficient or are not listed at all.

Despite the accumulation of a large volume of natural history data on the MH over the space of a century, many of the data have never been mobilised. Consequently it is difficult to provide quantitative assessments of biological richness and endemism that can be statistically compared with other mountain ranges in Africa. For instance, until Clark et al. (2017), only broad estimates of plant diversity and endemism in Nyanga – the second largest component of the MH – were possible, and it took almost 70 years for a detailed revised review of the most endemic-rich component of the MH – the Chimanimani mountains – to be published (Wursten et al., 2017). Furthermore, much available knowledge is unpublished and much of it held by elderly members of the public who have no funding to mobilise it. Most of this knowledge will be lost when these people pass away. Finally, with increasing human population in the mountains and associated land-use changes, there is need for current research and review of quantitative biological data.

### *3.1.4. Tourism*

The MH has traditionally been a strong tourism attraction and has large eco-tourism potential. Tourism used to be Zimbabwe's third largest earner of foreign exchange, and in 2016 Mozambique received 1,7 million international tourists (Nzengy'a, 2010; World Bank Group, 2015b; African Press Agency, 2016). The Government of Zimbabwe (2018) states that tourism, at 12%, is currently the second-largest sector of the Zimbabwean economy; and the Government of Mozambique (2014) states that the improvement of infrastructure for ecological, cultural and historical tourism is a priority for Mozambique.

Until the 2000s, the Zimbabwean side of the MH was a popular tourist area for domestic (mostly middle to upper class Zimbabweans), regional (especially South African) and international tourism. After a substantial slump mirroring the political and economic problems of that period, tourism is slowly on the increase again (Nzengy'a, 2010; Government of Zimbabwe, 2018). In Zimbabwe, conservation-based tourism is supported by two long-standing mountain national parks (Nyanga and Chimanimani), numerous indigenous forest reserves, a botanical garden and two botanical reserves.

In Mozambique the primary conservation area is the Reserva Nacional de Chimanimani, proclaimed in 2003 and is part of the Chimanimani TransFrontier Conservation Area (SADC, no date). Tourism in Mozambique has steadily increased after the Civil War ended in 1992 (World Travel and Tourism Council, 2018), supported by the removal of landmines (Landmine and Cluster Munition Monitor, 2017) and rehabilitated infrastructure (United Nations Development Programme (UNDP), 2004). The Reserva Nacional de Chimanimani and adjacent Moribane Forest Reserve have become popular, especially for elephant tracking and bird-tours (SADC, no date). The Micaia Foundation (http://micaia.org/) has been working with local communities to establish sustainable community-based tourism initiatives to diversify livelihoods and reduce negative environmental impacts.

Other MH incentives for tourism are the cooler temperatures (with a potential for 'climate-based tourism' in a warming world), crocodile- and bilharzia-free waters, absence of malaria, the scenic beauty, montane wildlife not typically found elsewhere in both country, and the unique montane flora (Lindsay and Martins, 1998). Bird-watching forms a particularly strong and well-developed specialist eco-tourism industry in the MH (Lloyd, 1997). Currently, most of the tourist infrastructure is on the Zimbabwean side, and tourist activities have traditionally included a wide spectrum, from adventure tourism, wilderness hiking and camping through to leisure getaways in self-catering units to up-market resorts, as well as trout-fishing and golf. Apart from the Reserva Nacional de Chimanimani there is currently limited tourism infrastructure elsewhere on the Mozambican side of the MH.

*3.1.5. Non-forest timber products*

Non-timber forest products cover a wide range of non-cultivated, commercial and non-commercial products extracted for economic gain and household use in forest and woodland regions of the World (Shackleton and Pandey, 2014; UNDP, 2017). Petheram et al. (2006) estimate that 320 million Africans depend on dry forests and woodlands to meet most of their basic needs. NTFP in the MH are undoubtedly used by local communities. It is almost certain that local communities have always benefited from NTFP in the MH, and this would have increased as a result of the economic challenges in Zimbabwe post-2000, especially during droughts when crop failure is high (Falayi, 2014; UNDP, 2017). In the MH, we could assume that most of the one million people living there rely on NTFP in some form. Likewise, the civil war in Mozambique would have forced most local people to use NTFP since the 1970s. Here we include food (wild-growing foods such as mushrooms and berries, and animal foods such as bush-meat, honey and insect larvae/pupae), natural medicines, items for cultural use, firewood and charcoal, and construction material as part of NTFP (Matsvange et al., 2016; UNDP, 2017).

Although NTFP is an extremely rich area of research in Africa, including Zimbabwe, quantifying use of NTFP in the MH is challenging. This is because the majority of environmental research to date in Zimbabwe and Mozambique has been on lower-altitude savannah woodland (the dominant vegetation type), and some on forest ecosystems (see Campbell, 1996; Mabugu et al., 1998; Grundy et al., 2000; Frost and Bond, 2008; Dewees et al., 2010; Adamowicz et al., 2012), with limited work done in grassland ecosystems (BirdLife Zimbabwe, 2012). As a result we have little quantitative information on NTFP extracted from montane systems such as the MH. Chapano and Mamuto (2003) provide a list of plants growing in the Chimanimani District (Zimbabwe) as a start to documenting species diversity with potential medicinal value.

Despite the reliance of poor communities on NTFP, currently the Forest Act and Communal Land Forest Produce Act in Zimbabwe prohibits commercial gain from non-timber forest products. This has been proposed for change in a draft Forest Policy (Zimbabwe Environmental Law Association, no date).

In general, there is concern that the use of NTFP in the region is unsustainable (Dovie, 2003). Our personal observations include Mutare residents felling the woodland around town for firewood, and on the Mozambican side of the Machipanda Borderpost, the woodland as far as Chimoio (90 km east) has been clear-felled for firewood. Excessive reliance to the detriment of woody vegetation is reflective of the national crisis in Zimbabwe: Tsiko (2017) indicates that all gazetted forest areas in Zimbabwe (including in the MH) have been invaded by informal settlers, with major impacts on woody vegetation and indigenous animals. This is resulting in conflict with long-standing communities adjacent to these protected areas; such communities have a vested interest in the preservation and sustainable use of these forests (Dovie, 2003; Matsvange et al., 2016; Tsiko, 2017). Tsiko (2017) suggests that the greatest culprit for unsustainable use of NTFP is inadequate governance, evident in the form of accepting bribes in exchange for unregulated logging, poaching, squatting, mineral 'rights', and other forms of resource extraction (The Herald, 2012).

### *3.1.6. Commercial forestry and highland agriculture*

The MH is Zimbabwe's most important commercial forestry region, supplying hard and softwoods from commercial species such as pines (notably Patula Pine *Pinus patula*), eucalypts (notably Saligna Gum *Eucalyptus grandis*) and wattle (notably Black Wattle *Acacia mearnsii*) (Mabugu et al., 1998; Mabugu and Chitiga, 2002). In 1998, 1556 $km^2$ of plantations were present on the Zimbabwean side, accounting for 80% of all commercial forestry in the country while only forming 0.4% of the land-cover (Mabugu et al., 1998; Mabugu and Chitiga, 2002). Ninety percent of these plantations were in the MH (Mabugu and Chitiga, 2002). The division between the timber-types was 71% pine, 13% eucalypts and 16% wattle while ownership of plantations was 42% state (managed by the Forestry Commission), 54% private companies, and the remainder by small-scale timber growers (Mabugu et al., 1998; Mabugu and Chitiga, 2002). Mabugu and Chitiga (2002) assess commercial forest stock in detail (up to the year 2000), but no not provide an overall value of commercial forestry to the Zimbabwean economy other than the government statistic of 3%. Commercial forestry is less developed on the Mozambique side, being confined mostly to the Penhalonga and Rotanda areas and estimated at 166 $km^2$ (South African Forestry Company Limited, SAFCOL, 2010). Due to the political and economic challenges in Zimbabwe since 2000, some commercial timber activity may have relocated to Mozambique, with potential resultant impacts on water, biodiversity and the spread of IAS (SLC, unpublished data). Tsiko (2017) indicates that commercial forestry on the Zimbabwe side has been heavily impacted by informal settlers, arson and artisanal mining in recent years. Of all the ES considered in this paper, commercial forestry is the only one assessed in any detail

The MH provides climates and soils that allow for agricultural products that cannot as easily be produced elsewhere in Zimbabwe and Mozambique (Energy Sector Background for Manicaland Province, no date), and productivity as an agricultural areas dates back centuries; the Portuguese recorded obtaining provisions from the Bvumba in the 18$^{th}$ and 19$^{th}$ centuries (Bannerman, no date). Modern produce comprises commercial and cash crops of tea, coffee, macadamias, avocados, potatoes, vegetables, cut flowers, bananas, apples, pears peaches and cool weather vegetables. The MH is the main fruit producing area of Zimbabwe. The politically-driven land tenure conflict has been the main hindrance to a thriving agricultural sector in the MH in recent years. In Zimbabwe, subsistence agriculture has become more prevalent since 2000, as many commercial farmers were forced to abandon their farms during the controversial Fast Track Land Reform Programme (Cliffe et al., 2013). This left several million former farm employees without work, driving many to subsistence farming, artisanal mining, emigration, or as refugees, especially to South Africa and Mozambique. Few former commercial farms have been rendered commercially viable by the new 'owners', and are also now mostly small-scale subsistence enterprises that only use a small portion of the original agricultural land (Cliffe et al., 2013; Energy Sector Background for Manicaland Province, no date).

Tea production has remained reasonably stable, and even in the early-2000s, both Zimbabwe and Mozambique were among the top 20 growers of tea in the world (Cliffe et al., 2013). In 2003 they ranked 5$^{th}$ and 7$^{th}$ respectively out of the seven top African tea producers (Butler, 2005). Tea production in the MH dates to the 1920s, where the first plantations were developed in Chipinge, and currently occupies approximately 50 $km^2$ on the Zimbabwean side and perhaps four square kilometers on the Mozambican side (Butler, 2005). Like commercial forestry operators, large tea producers have been investigating expanding operations into the Mozambican side of the MH to spread risk and increase foreign income (Butler, 2005). These large-scale plantations – run by a few large companies – have since the 1960s also invested in 'tea out-grower' schemes in which local small-scale farmers participate in tea-growing as a cash crop to augment overall production (Mtsisi, 2003).

Natural grass-dominated rangeland is one of the main producers of agricultural commodities, especially in grassland-dominated ecosystems (Klein et al., 2019). This is true for the MH in the form of communal grazing of cattle, goats, horses, donkeys and sheep (e.g. the Gaireza area north of Nyanga National Park). The current state of commercial livestock ranging in the MH is uncertain. Herbivores native to the montane grasslands of the MH (such as Blesbuck *Damaliscus pygargus phillipsi*, Eland *Taurotragus oryx*, Mountain Reedbuck *Redunca fulvorufula*, Burchell's Zebra *Equus quagga burchellii* and Waterbuck *Kobus ellipsiprymnus*) could be included in this concept of ES, as they provide a tourist attraction (notably to Nyanga National Park) reliant on montane grassland productivity.

*3.1.8. Historical, cultural and spiritual value*

The MH has been continuously settled since at least the Early Stone Age, with successive waves of immigrants and emigration, from the San through Iron-Age tribes, to European Settlers in the late 1800s (Bannerman, no date) and an increasing Asian (Chinese) influence in recent years. As a result the MH has a plethora of sites of historical, cultural and spiritual value in the form of archaeological sites, sacred forests and pools (for coronations, rituals and rain-making ceremonies), rock paintings, and battle sites (Bannerman, no date; Mupira, no date; Ransford and Steyn, 1975; Kritzinger, 2012b).

The Nyanga area contains the greatest concentration of ancient ruins in Zimbabwe (Mupira, no date; Ransford and Steyn, 1975; Soper 2002, 2007). These ruins include 'slave pits', extensive hillside terracing, small stone forts, and extensive stone-works (Ransford and Steyn, 1975). Contact between local Shona Kingdoms dates back to the early 1600s, as is reported in Portuguese archives (Bannerman, no date; Kritzinger, 2012b). The presence of European settlers, such as the Moodie Trek from South Africa to the Chipinge area in 1892, has left its own historical legacy (Ransford and Steyn, 1975).

*3.2. Potential threats to Manica Highlands' ecosystem services*

*3.2.1. Invasive alien species*

Invasive alien plants (IAS) in the MH have been a known problem since at least the 1980s (Childes, 1997). Most of the main problem species also cause challenges elsewhere in southern Africa, being those introduced for commercial forestry and through horticulture (Lyut et al., 1986; Nyoka and Musokonyi, 2002; Nyoka, 2003). Currently the most dominant invasive plants are fire-driven or fire tolerant woody species, particularly Patula

Pine, Black Wattle, Silver Wattle *Acacia dealbata*, Australian Blackwood *A. melanoxylon* and Saligna Gum (Nyoka, 2003).

Information on the current extent of IAS in the MH is not available. By 2003 (latest date for which data are available) Patula Pine – considered to be one of the most serious montane invaders in southern Africa (Moran et al., 2000) – was estimated to have invaded as much as 1000 $km^2$ (12%) of the MH, and Black Wattle – one of the top worst invaders globally – was estimated to have invaded c.2000 $km^2$ (24%; Nyoka, 2003); together this totals 36% of the MH. A total of 53 $km^2$ is indicated by the Governments of Mozambique and Zimbabwe (2006) as being invaded by woody aliens, but this is in conflict with other data and new data are needed. The endemic-rich moorlands, wetlands and riparian zones have been the most seriously affected by woody invasive species, although indigenous and riparian forests have also been affected (Childes, 1997; Tafangombe, 2001; van Wyk and Smith, 2001; Nyoka, 2003).

In the 470 $km^2$ Nyanga National Park there was a ten-fold increase in alien plant coverage between 1960 and 1999, affecting up to 40% of the Park (Childes, 1997; Childes and Mundy, 2001). A field mapping exercise in 2016 by VRC (unpublished) indicated that there was no part of the Park that was not affected by woody invaders, including the most remote areas such as the summit of Mount Nyangani at 2593 m, and the extensive and isolated Pungwe plateau. A number of other species (woody and other) are more problematic locally, such as Khalili Ginger Lily *Hedychium gardenerianum* and 'Bee Bush' *Vernonanthura polyanthes* (=*V. phosphorica*) in the Bvumba forests (Ngarakana and Kativu, 2018). The latter is a recently recognised invader originating from Brazil (Sukhorukov et al., 2017) and for which there is little ecological knowledge for management. It has also invaded large areas of the Mozambican side of the MH (Grundy, pers.com.). Cyclone Idai (March 2019) – penetrating across deep into Zimbabwe – may have further spread the wind-borne seeds of this species, perhaps even into northern South Africa.

Invasions also affect parts of the Chimanimani National Park, although not to the same extent as in Nyanga. But both Nyanga and Chimanimani National Parks were considered to have deteriorated from a 'moderate' to 'poor' state between 2001 and 2008, IAS being highlighted as the main reason (Mukwashi and Matsvimbo, 2008). Most private land is also seriously affected, with knowledge, interest and participation in addressing the situation by the public being limited (Nyoka, 2003). Much of the best practice alien control action implemented by local committees and commercial forestry companies has been halted since the early 2000s in Zimbabwe (Dansereau and Zamponi, 2005).

Afromontane and endemic biodiversity is at high risk and several species are directly impacted by commercial forestry and woody IAS. Blue Swallow numbers have been decreasing in recent annual surveys, Wattled Crane requires intact montane grassland, and *Prunus africana* is being outcompeted by more vigorous alien trees (Mukwashi and Matsvimbo, 2008; Jimu and Ngoroyemoto, 2011). The impacts of introduced Rainbow Trout *Oncorhychus mykiss* and Brown Trout *Salmo truta* on freshwater diversity and ecology in the MH is also a concern (Kadye et al., 2013). Based on studies in South Africa and Malawi this is likely to have negative impacts on indigenous and endemic aquatic biodiversity (Millington and Kaferawanthu, 2005). Few studies have been carried out to assess the impact of invasion within aquatic ecosystems in the MH and overall this ecosystem is poorly known.

Although Maroyi (2012) provided the first list of naturalised alien plant species for Zimbabwe, there is no list of invasive or potentially invasive plant and animal species for the MH, or data on their extents, rates of expansion, impacts on ES and biodiversity, or the potential exacerbation by climate change (Urlich et al., 2014; Petipierre et al. 2016), by which to guide policy and mitigation measures.

The impacts of these high water-use plant species on the provision of ES (Versfeld et al., 1998) have never been calculated for the MH, but as a comparison, some montane catchments in South Africa experienced a 50–100% reduction in local stream flow after transformation into an alien woody environment through forestry or feral invasion (Moran et al., 2000; Görgens and Van Wilgen, 2004). Feral woody invaders thus rob immediate and downstream beneficiaries of valuable water, and render land economically unproductive, reducing livelihood options and the potential to improve local economic conditions.

On a national level, the full extent of the impact of IAS is not known in either Zimbabwe or Mozambique, and the costs of an effective management plan have not been calculated (Nyoka, 2003). IAS are found in 73% of the IBAs in Protected Areas in Zimbabwe (Mukwashi and Matsvimbo, 2008). Both countries are signatories to the Convention on Biological Diversity, which includes a commitment to combatting IAS. Accordingly, the Environmental Management Act of Zimbabwe (EMAZ) has included invasive plant species as a potential threat to ecosystems in Zimbabwe. The (then) Zimbabwean Ministry of Environment, Climate and Natural Resources Management recommended the need for quantification and mapping of invasion sites across the country as a way of ascertaining the associated environmental costs. This information is essential for the development of control strategies and estimation of cost of controlling IAS. To date most effort and expense towards alien control in Zimbabwe has been aimed at agricultural pests and invasive aquatic plants (see Lyons and Miller, 2000; MacDonald et al., 2003). Meeting national targets on other IAS has been hampered by lack of technical expertise and funds, especially in national parks. In Mozambique, primarily a lowland country, most efforts on IAS in the past have been focused on aquatic weeds and agricultural pests (MacDonald et al., 2003).

Zimbabwe and Mozambique have benefitted from South Africa's world renowned biocontrol research programmes, for example, the natural spread of agents across the border in controlling the Teddy Bear Cholla *Cylindropuntia bigelovii* and the Eucalyptus Gall Wasp *Leptocybe invasa* (a forestry pest). The same may happen for other biocontrol agents released in South Africa (De Lange and Van Wilgen, 2010) to combat problem MH species, e.g. Black Wattle, but it is not known how long it will take these agents to reach the MH populations naturally since the MH is separated from South African populations by c.300 km of unfavourable lowland savannah. Piggybacking on South Africa's biological control experiences (De Lange and Van Wilgen, 2010) may be the only realistic long term means of overcoming woody alien invasions in the MH (Moran et al., 2000). How long it would take to be officially approved in Zimbabwean and Mozambique is not certain however, nor if such a move would be favourably received by the local commercial timber companies. In South Africa there are currently suitably screened biocontrol agents for most of the problematic MH woody plants and many of the non-woody species, and approved integrated management methods for many others.

### *3.2.2. Land-use change*

Because the MH has been settled for at least the last 2000 years by pastoralists, croppers and mining communities (Bannerman, no date; Kritzinger, 2012a, b), it is probable that none – or very little – of the vegetation in the MH can be considered 'pristine'. The past, extensive landscape modification in Nyanga through the stripping of soil on gold-bearing granite slopes (Kritzinger, 2012a), for instance, suggests major impacts on the montane grasslands and associated biodiversity as far back as 1000 years ago. Bannerman (no date) suggests that the only areas in the Bvumba not affected by distant human activities were Bunga Forest and forests on the Zohwe and Ndirondongue ranges. The exception could be the Chimanimani mountains, which are too rugged, cold and wet for settlements, and the soil is too poor for cultivation; however the Chimanimanis comprise only 7% of the total MH.

More recently, extensive commercial agriculture, afforestation and industrial mining, as well as concentration of African peoples into 'tribal trustlands' in the first half of the 20th century together with associated population growth, have resulted in major land-use changes in the MH. Further changes on a landscape scale have taken place following the Fast Track Land Reform Programme in Zimbabwe from 2000 onwards – the social, economic and environmental implications of which will be ongoing in the MH for the foreseeable future.

As a result of the constant changes to the landscape over time, it is difficult to determine a baseline against which to measure change. As a result, we simply list the changes that have predominated since the late 19th century, but they might not be reflective of cumulative (and unknown) changes that took place before then:

(1) Extirpation of mega-fauna (elephant, hippopotamus, crocodile, buffalo, rhinoceros, lion, etc.) from the MH and adjacent lowland savannahs.
(2) Partitioning of the MH into British and Portuguese territories, with different policies, management and agendas on each side of the border.
(3) Creation of 'tribal trust' lands as separate to white colonial land.
(4) Conversion of montane grassland and lowland forests to commercial and subsistence vegetable, cut flower, tea, coffee and fruit farming.
(5) Conversion of montane grassland to commercial forestry (afforestation).
(6) Invasion by IAS of montane grasslands, forests, and riparian zones.
(7) The creation of numerous urban areas and areas of dense small-holdings.
(8) Extensive dam building.
(9) The Bush War in Rhodesia (late 1970s) and the Civil War in Mozambique (1977–1992) resulted in extensive clearing of vegetation along the international border and the laying of land mine fields.
(10) The Mozambican Civil War resulted in mass refugee exodus to Zimbabwe, extreme poverty in Mozambique, and direct impacts on the environment.
(11) Industrial mining in the Penhalonga area.
(12) Proclamation of numerous protected areas and the creation of the Chimanimani Transfrontier Park.
(13) The Fast Track Land Reform Programme in Zimbabwe that resulted in a resurgence of woody IAS into montane grassland, *ad hoc* fire regimes, and former agricultural lands reverting to secondary growth, as well as mass emigration of farm workers to Mozambique from Zimbabwe.
(14) Dramatic increase in artisanal mining, notably in the Chimanimanis.
(15) Cyclone Idai and the social and ecological impacts on the MH area, which was hard hit.

While it is difficult to know what the cumulative impact of land-use change on MH ES over the centuries has been, it may be feasible to begin an annual land-use change survey using remote sensing and GIS to track changes and the implications for natural resource accounting.

*3.2.3. Climate change*

Mountains are considered to be especially vulnerable to climate change (Spehn et al., 2010; Spehn, 2011; Kohler et al., 2014; Mountain Research Initiative EDW Working Group, 2015; Klein et al., 2019). It is not clear how the MH might be impacted by climate change. Although neither Zimbabwe nor Mozambique contributes significantly to global carbon emissions – Zimbabwe's $CO_2$ emissions in 2017 were 0.73 tonnes/capita, while Mozambique's was 0.26 tonnes/capita, compared to the global average of 4.91 (Muntean et al., 2018) – both countries are highly vulnerable to climate change impacts (DARA and the Climate Vulnerable Forum, 2012; Government of Mozambique, 2014; African Development Bank: African Development Fund, 2018). Based on the Global Climate Risk Index, Mozambique had the most weather-related loss events (implied from climate change) of any country in 2015 (Kreft et al., 2017), while in 2017 it ranked 28th (Eckstein et al., 2019); Zimbabwe ranked 14th in 2015, and 51st in 2017 (Kreft et al., 2017; Eckstein et al., 2019). Following a first historical record of two cyclones (Cyclones Idai and Kenneth) making landfall in one season in 2019 in Mozambique (United Nations Children's Fund (UNICEF), 2019), with the Idai also entering Zimbabwe, plus persistent drought over much of Zimbabwe in 2018–2019 (Masante and de Jager, 2019), both countries might be high up in the 2019 rankings. With 70% of the population of Zimbabwe being rural and relying largely on subsistence agriculture in a drought-prone region (Intergovernmental Panel on Climate Change (IPCC), 2019), this is a high-risk region for climate change impacts (Ministry of Environment and Natural Resources Management, 2013; Sango and Godwell, 2015; Masante and de Jager, 2019). Increasing climate variability since the 1960s is showing signs of significantly deteriorating ecosystems services, impacting food security, hampering development and increasing poverty in parts of Zimbabwe (Brown et al., 2012; Ministry of Environment and Natural Resources Management, 2013; Sango and Godwell, 2014).

Apart from a few local studies, including on forests in general, the Odzi-sub-catchment, and recordings of community-based change experiences (Matarira and Mwamuka, 1996; Mweembe, 2013; Nyoni et al., 2013; Matimaire, 2015), there has been no climate change research focused on the MH.

As for most of southern Africa, there have been various broad-scale predictions on how the region might be impacted by climate change (Hulme and Sheard, 1999; Chagutah, 2010; Engelbrecht et al, 2011; Engelbrecht, 2012; Ziervogel et al., 2014). Zimbabwe's Initial National Communication under the United Nations Framework Convention on Climate Change (Ministry of Mines, Environment and Tourism, 1998) suggested that climate change could cause the rivers in the MH of Zimbabwe to change from perennial to seasonal. More recently, the Zimbabwe Strategy on Climate Change (Ministry of Environment and Natural Resources Management, 2013) suggested that the MH has the greatest adaptive capacity and may not be much impacted at all. From extensive biodiversity stakeholder capacity building meetings, conducted by BirdLife Zimbabwe between 2013 and 2015, two examples of local perceptions of climate change effects have been noted. The first is that trees in the Bvumba rainforests have begun to shed their leaves at certain times of the year, something that did not happen in the past. The second is that soil moisture in Chirinda rainforest is no longer perennial but seasonal. There have also been reports of increasing malaria incidence at higher altitudes, as elsewhere in Africa, although in Zimbabwe this could be due to lapses in effective management and the vector is simply reclaiming former territory. The reported presence of lower altitude ticks now at higher altitudes has also been raised by communities. Obviously such examples need to be empirically explored and all causal possibilities considered.

*3.2.4 Mining*

While the MH has traditionally not been considered as mineral-rich as other parts of Zimbabwe and Mozambique, mining has formed a strong component of human activities in the MH for centuries (Huffman, 1974; Kritzinger, 2012b). Two gold belts – the Makaha and Penhalonga – run through the MH in an east-west direction (Kritzinger, 2012a), with the more recent extensive artisanal activities in the Chimanimanis (Dondeyne and Ndunguru, 2014) suggesting a third. The Penhalonga belt (also called the Mutare Greenstone Belt) has been mined as far back as at least the 1500s (Bannerman, no date), and continues to be mined today in both commercial and artisanal manners (Ndunguru et al., 2006; Worl and Sterk, 2012; Prospect Resources Ltd, 2018). The Soper (2002, 2007)-Kritzinger (2012a) debate (that ancient terracing and pit structures which characterise Nyanga in Zimbabwe reflect extensive precolonial gold processing associated with the Makaha belt rather than agricultural activities) suggests that mining for precious metals has played an important part in the social-ecological history of the MH, affecting social composition, landscape form, and natural history. There has been a more recent resurge of interest in the MH as a source of minerals, including the first aeromagnetic survey (2012) of the MH since 1980 (The Chronicle, 2012). In addition to gold, the MH has known proven bodies of bauxite in Penhalonga (Mina Alumina, no date) and possibly in Nyanga (allAfrica.com, 2008; Minerals Marketing Corporation of Zimbabwe, 2014). The Marange diamond controversy on the western edge of the MH from 2008 onwards (McGreal, 2008), and later diamond discoveries in the Chimanimani area (Environmental Justice, 2014; Minerals Marketing Corporation of Zimbabwe, 2014; Ministry of Mines and Mining Development, 2016b), suggests that there may be other diamond deposits in the region. Other minerals known to occur in the MH include copper, cordierite, molybdenum, sapphire, silver, talc, tantalum, tin, topaz, tungsten, vermiculite and zinc (Minerals Marketing Corporation of Zimbabwe, 2014; Ministry of Mines and Mining Development, 2016b; Mindat.org, 2018).

The annual value of artisanal gold mining in Mozambique is estimated by Dondeyne and Ndunguru (2014) at between US$19-29 million, employing some 60,000 people out of a total artisanal mining population of c.150,000 people. Artisanal gold mining was officially banned in Zimbabwe in 2006/2007, but currently some 400,000 people (locally termed 'makorakoza'; Kritzinger, 2012a) are estimated to be engaged in such activities through livelihood necessity (Dalu et al., 2017).

Environmental impacts in the MH from artisanal mining include riparian zone destabilisation/transformation; increased sediment loads in rivers; mercury and cyanide pollution; negative impacts on endemic biodiversity; damage to forestry plantations; hunting of bush meat for food by miners; use of indigenous trees for mine props, fires and implements; and personal risk of injury and death (Governments of Mozambique and Zimbabwe, 2006; Ndunguru et al., 2006; allAfrica.com, 2012; Metcalf and Veiga, 2012; Dondeyne and Ndunguru, 2014; Dalu et al., 2017). Environmental impacts from industrial scale mining involve large-scale habitat transformation, and often persist over time (Jonnalagadda and Mhere, 2001; Jerie and Sibanda, 2010), although theoretically these are mitigated through formal environmental management plans (Dalu et al., 2017). Given the centuries of mining activity in the MH, it is difficult to know what impact mining has had on the environment over this time: it is possible, for instance, that the low levels of endemism in Nyanga – compared to the rugged Chimanimanis – may be due to extinctions resulting from centuries of mining activities and associated major landscape transformation, although it is unlikely this could ever be tested.

In economic and political climates like Zimbabwe and Mozambique that have disenfranchised rural communities, artisanal mining is often the only feasible livelihood option for many of the poor (Dondeyne and Ndunguru, 2014). As a result, artisanal mining in both Zimbabwe and Mozambique is unlikely to disappear, and both governments have attempted to regularise this sector. Dondeyne and Ndunguru (2014) indicate that governments face three major challenges regarding artisanal mining: (1) ensuring that trading is formalised such that national revenues and foreign exchange are not lost to the country; (2) ensuring that the safety of miners is maximised while health hazards for the general public are minimised; and (3) minimising the environmental consequences of often chaotic exploitation. From being in the past indifferent to artisanal miners in Zimbabwe, the Zimbabwean Ministry of Mines and Mining Development proposed in 2017 that one million hectares of protected land in Zimbabwe (including the endemic-rich Chimanimani mountains) be de-proclaimed and made available for artisanal mining. At the same time pressure is being placed on Zimbabwe's Environmental Management Agency to waive Environmental Impact Assessment requirements for artisanal mining, despite this being some of the most environmentally destructive and unregulated mining in Zimbabwe. De-proclamation of Nyanga and Chimanimani National Parks would change the MH from currently being among the most protected montane areas in southern Africa (per unit area) to one of the least protected. In Zimbabwe, mining is highly politicised and often associated with army or police violence against civilians (Gonda, 2008; McGreal, 2008; Andersson, 2011; Environmental Justice, 2014), resulting in probable under-reporting of environmental impacts and human rights abuse. In terms of mining and national responsibility, the Natural Resource Governance Institute (NRGI, 2017b) places Zimbabwe at 81$^{st}$ out of 89 countries assessed on the Resource Governance Index (RGI); the reason for Zimbabwe's "Failing" status is listed as "characterised by failing institutions". Zimbabwe also ranked the second-lowest of 31 sub-Saharan countries assessed (NRGI, 2017b). A positive indication is that the Government of Zimbabwe has committed to the following, under the section "Fighting Corruption" of the document '*Towards an upper-middle income economy by 2030*' (Government of Zimbabwe, 2018, p.46: '*221. In the mining sector, there is need for greater transparency and accountability in the management of mineral revenue and Government will improve mineral governance, including adoption of international best practices, benefitting from the Extractive Industry Transparency Initiative (EITI).*' However there is no indication in the document of mitigating environmental issues related to mining or controls on mining in protected areas or sensitive habitats. Mozambique is showing the most success in regularising the artisanal industry, but usually only where reef ore is mined, as placer ore (usually in alluvial or colluvial contexts) is typically a 'boom and bust' mining scenario of short duration but high environmental impact (Dondeyne and Ndunguru, 2014). The NRGI (2017a) places Mozambique at 41$^{st}$ out of 89, i.e. "Weak", on the RGI, and it ranks 12$^{th}$ out of 31 sub-Saharan countries assessed; it is in a much stronger position than Zimbabwe at present, and is therefore more likely to implement good practice and appropriate environmental instruments in the mining sector as affecting the MH.

The long-term vision documents of both Zimbabwe and Mozambique have a high emphasis on mineral exploration and exploitation (Government of Mozambique, 2014; Government of Zimbabwe, 2018), which would extend naturally to the mineral-rich MH. It is hoped – based in particular on Zimbabwe's recent commitment to transparency in the mining sector (Government of Zimbabwe, 2018) – that there will be continued commitment to (from Mozambique) and revitalisation of (from Zimbabwe) good practice in terms of social and environmental tools (such as Social and Environmental Impact Assessments and Environmental Management Plans) to promoting rehabilitation and ecological sustainability in mineral-rich areas of the MH, and that protected areas will remain as such.

*3.3. The Manica Highlands, legislation and policies*

Based on the ES provided by the MH, combined with the threats to these, specific policy is needed for the MH that addresses its unique context within Zimbabwe and Mozambique. Synergies among those policies should be realised, policies should 'talk' to each other and strengthen the TFCA agreements/strategies and avoid increased threats to the MH. The rationale for this is explained by exploring why mountains in general require focused policy and legislation at a national and trans-boundary scale to make sustainable management a possibility.

*3.3.1. Mountains require focussed policy and legislation for their sustainable management*

Klein et al. (2019) indicate that one of the largest threats to mountain ES globally is policy being developed and imposed from outside mountain areas – policy-makers are not familiar with mountain-generated ES nor with mountains as SES. Despite the intuitive value of ES provided by mountains, mountain-specific legislation and policy is a relatively recent development, with only a few national and international mountain-specific policies in place before the 1992 Rio Convention (FAO, 2002). Notably some of the first pre-Rio policy tools were in Africa, such as South Africa's Mountain Catchment Areas Act of 1970 and Regulations of 1971, which was also applicable to Namibia at the time. Agenda 21 (emanating from Rio 1992; Chapter 13) specifically recognizes the ES provided by mountains, and Rio+20's '*The future we want*' includes three paragraphs with a mountain focus. Significantly, Chapter 13 of Agenda 21 was the result of input from the African Mountains Association (AMA), formed in 1986 to reduce isolation among scientists working on African mountains and which included a delegation from Zimbabwe (Sustainable Development in Mountain Ecosystems of Africa, 1996). Chapter 13 of Agenda 21 provided a global platform on which to build mountain-related conventions, treaties and policies. This resulted in numerous soft law instruments such as the Charter for the Protection of the Pyrénées in 1995; the African Mountains and Highlands Declaration of 1997; the Kathmandu Declaration, also in 1997; the Euromontana Final Declaration in 2000; the Cusco Declaration on Sustainable Development of Mountain Ecosystems in 2001; the Central Asian Charter for the Sustainable Development of Mountain Regions in 2002 (FAO, 2002); and the First African Mountains Regional Forum in 2014 (International Institute for Sustainable Development (IISD), 2014). The Millennium Ecosystem Assessment provided a dedicated focus on mountains (Körner et al. 2005), and advocacy for mountains and mountain communities – and associated policies and actions – has steadily increased through the activities of the organisations such as the Mountain Research Initiative, the Mountain Partnership, The Mountain Institute, the International Centre for Integrated Mountain Development, UniMont, the Global Mountain Safeguard Programme, and others.

*3.3.2. Mountains require specific policy and legislation at a national level*

FAO (2002) provided a Eurocentric review of mountain-tailored national legislation since 1992 in their review of mountain-specific policy and legislation, and failed to mention the numerous African examples of pre-Rio 1992 international mountain co-operation. Africa, while plagued by numerous obstacles to more widespread implementation and successful management, has been a global leader in pioneering mountain-related legislation and trans-boundary co-operation. Despite this, Africa is largely absent from the international mountain research and policy platform (Körner, 2009).

Although African experience in mountain-related policy and co-operation is not new, UNEP (2014) states that there is a notable lack of legislation in Africa encouraging sustainable development in mountain areas and the wise use of mountain-generated ES. Nevertheless, there are several mountain-specific sets of national legislation that can be used as examples to develop these in other African countries, as well as to inform regional policy. Examples of mountain policy that can be achieved include South Africa's Mountain Catchment Areas Act (MCAA) of 1970; Uganda's 'Guidelines on the management of hilly and mountainous areas' followed by the National Environment (Mountainous and Hilly Areas Management) Regulations (No. 3 of 2000); and Nigeria's National Environmental Regulations (Watershed, Mountainous, Hilly and Catchments Areas) of 2009.

There is also much relevant law 'hidden' in other forms of national legislation, Africa-specific conventions, and international agreements (FAO, 2002). Others can be found which deal *inter alia* with minerals, health, soil conservation, agricultural weeds and the promulgation of conservation areas, while not being tailored *per se* to the unique conditions or needs of mountain areas. Examples are Burundi's Forest Act of 1985, Uganda's National Environment (Minimum Standards for Management of Soil Quality) Regulations (S.I. No. 59 of 2001) and Tanzania's Environmental Management Act (No. 20 of 2004).

While not specifically aimed at mountains, some countries are encouraging public-private partnerships to facilitate sustainable development and environmental conservation. The Biodiversity Stewardship South Africa (BSSA) programme, implemented by the South African Department of Environmental Affairs (DEA), is one of these and focuses on areas in South Africa with high biodiversity and ecosystems services value (South African National Biodiversity Institute (SANBI), 2014). Perhaps the most spectacular success story using this approach has been the declaration of the Ekangala Grasslands Protected Natural Environment, covering 1.6 million hectares of high water-yielding but endangered high altitude grassland along South Africa's eastern Great Escarpment. The project involves co-operation between national and provincial conservation organs of state, private landowners, local communities and key NGOs such as BirdLife South Africa, the Endangered Wildlife Trust and the WWF. In many parts of Africa it is NGOs that have stepped in to fulfil the conservation functions of often understaffed and under-financed national conservation authorities. An example of this is BirdLife International, which has had success in reversing forest degeneration in the Bamenda Highlands of Cameroon through enabling the community to practice sustainable forest management (BirdLife International, 2008).

### *3.3.3. Mountains are globally a trans-national management issue*

The management of mountain environments is traditionally a trans-national matter of global and diplomatic significance (Price, 2015). This is because in many parts of the world mountains have traditionally been designated as the boundaries of political entities, although the flow of ES does not recognise political borders. The only continents that do not have a large degree of mountain-sharing between nations are North America, while Europe, Asia, South America and Africa exhibit high cross-border mountain-sharing. Furthermore, in many parts of the world, the mountains in one country provide ES which are of benefit to other near and far lowland countries. In

Africa obvious examples are the Nile, Niger and Okavango Rivers, and a remarkable exception is the Congo. This requires a co-operative approach between nations for the management of ES in terms of the implied requirements of international customary law (FAO, 2002), and requires participation at all levels of society (UNEP, 2014). Successful trans-national management of ES requires quantifying threats and devising strategies that transcend linguistic, worldview, political and socio-economic differences (UNEP, 2014).

Cross-border mountain-sharing and management is not new to Africa, with conservation efforts being increased in recent decades (UNEP, 2014). For example, trans-boundary management of the Virunga Mountains (the 'Greater Virunga Landscape') dates back to the 1920s (UNEP, 2014), well before FAO's (2002) mention of the 'first' trans-boundary agreement (the Alpine Convention of 1991). African trans-boundary management agreements reflect the scattered and diverse nature of mountains in Africa. Recent examples of successful trans-boundary protected areas and agreements are the 175 $km^2$ Mount Nimba Strict Reserve (Guinea-Ivory Coast), established in 1981; the 1000 $km^2$ Nyungwe-Kibira ecosystem, managed jointly by a 10-year Transboundary Strategic Plan (Rwanda-Burundi); and the Central Albertine Transfrontier Protected Area Network, covering the Kibale, Mgahinga Gorilla, Queen Elizabeth, Rwenzori Mountains, Semuliki, Virunga and Volcanoes National Parks and Bwindi Impenetrable Forest (DRC, Rwanda and Uganda). Currently, perhaps the most (potentially) effective instrument for cross-border mountain management in southern Africa is the SADC Transfrontier Conservation Area (TFCA) Programme, developed under the SADC Protocol on Wildlife Conservation and Law Enforcement 1999 (SADC, 2012a, 2013). Although it is not a mountain-specific instrument, it does include five TFCA's (out of 18 that are in various stages of agreement) that include mountains (SADC, 2012b): the 5920 $km^2$ /Ais/Ais-Richtersveld TFCA (the Richtersveld mountains, on the western Great Escarpment), the 4091 $km^2$ Chimanimani TFCA (including the Chimanimani mountains, in the MH), the 37572 $km^2$ Great Limpopo TFCA (which includes the Lebombo Mountains), the 30621 $km^2$ Zambia-Malawi (Nyika) TFCA (the Nyika Plateau), and the 8113 $km^2$ Maloti-Drakensberg TFCA (which includes 20% of the 40000 $km^2$ Maloti-Drakensberg and in 2013 was designated as a UNESCO World Heritage Site).

In addition to trans-boundary conservation areas, formal and informal research collaborations and initiatives on African mountains include AfroMont (the African chapter of the MRI, with continent-wide focus), *Valuing the Arc* (Eastern Arc Mountains, Tanzania), the Albertine Rift Conservation Society (Albertine Rift), the Great Escarpment Biodiversity Research Programme (southern Africa) and the MHI. Global research groups such as the Mountain Invasion Research Network (MIREN) also have an African focus. Programmes focused on socio-economic issues in mountain areas include the African Highlands Initiative (AHI), founded in 2006 to improve the livelihoods of the densely populated mountain areas of Ethiopia, Kenya, Tanzania, Rwanda and Uganda (AHI, 2006).

Nationally, trans-boundary mountain-related legal tools are often embedded within other forms of trans-national agreements. For example, the East African Community Treaty (effective since 2000 and binding on Burundi, Kenya, Rwanda, Tanzania and Uganda) includes components relating to environmental management, actions, tourism, wildlife management and integration of conservation management policies. This gave rise to the Protocol on Environment and Natural Resources Management, Article 20 of which is specifically focused on mountain environments (UNEP, 2014). International mountain-related policy can also be found in continent-scale frameworks, such as the New Partnership for Africa's Developments (NEPAD) Action Plan for the Environment, which outlines the need to manage watersheds across the continent (NEPAD, 2003), and the Lusaka Agreement on Cooperative Enforcement Operations Directed at Illegal Trade in Wild Fauna and Flora actioned in 1996 (Lusaka Agreement Task Force (LATF), 2013). International agreements over specific resources are also a vehicle for international mountain policy, such as the Komati Basin Project (South Africa and Swaziland) and the Lesotho Highlands Water Project (Lesotho and South Africa).

Where mountains are part of conflict zones, resource management is more difficult to implement (Hanson et al., 2009). Current examples are the Kashmir region (Pakistan-India) and the Golan Heights (Syria-Israel). Historically the MH has been part of a conflict zone, during the Rhodesian Bush War and the Mozambican Civil War, and parts of the international border through the MH are still land mined from these conflicts.

The current political boundary along the MH was defined by the two previous colonial governments in the late 1800s and has no resemblance to ethnic, topographical or biological features on the ground (Bannerman, no date). The long-term effective management of the ES provided by the MH will therefore require careful co-operation between these two countries by aligning their goals and objectives for this region through *inter alia* dovetailing of existing policies. This is particularly relevant in terms of IAS and water supplies. The two countries have co-operated closely in the region before, notably in the Chimanimani Transfrontier Conservation Area (detailed above), as well as in tackling issues around illegal artisanal gold mining in protected areas. Challenges to such co-operation include low priority of the MH on national agendas: neither Zimbabwe nor Mozambique refer specifically to mountains, the MH or ecosystem services in their long-term plans (Government of Mozambique, 2014; Government of Zimbabwe, 2018), although understandably such documents are inherently generic. Klein et al. (2019) note that “one of the most ubiquitous challenges facing mountain systems is that policies directly affecting mountain systems are being made by those living outside of the mountains themselves” – this is particularly true for the MH, where advocates for local sustainability are required to travel to main centres to advocate to policy-makers and government for reversal of decisions that affect mountain communities livelihoods and ecological sustainability.

## 4. Conclusion

Southern African mountains are under-researched and under-represented as social-ecological systems, and feature sparsely in the global mountain research and policy arena. Yet the ecosystem services these mountains provide are key to ensuring a sustainable future for the Southern African Development Community region.

We show that the Manica Highlands, as a first comprehensive case review on a southern African mountain system, do not have national or trans-boundary focus policies for the sustainability of the ecosystem services they provide, including mitigations against threats. Being marginal to national interest, yet critical to providing nationally-important ecosystem services (especially water), the Manica Highlands should be a priority for trans-national research and diplomatic dialogue. Currently, there is conflict between national priorities (e.g. mineral extraction at the expense of water production landscapes), and potential philosophical conflict between conventional climate change mitigation ideals and actual realities (e.g. carbon sequestration – easily assumed to mean to promote the planting of woody non-native species in natural montane grassland – and water production and biodiversity conservation).

We encourage a holistic, transdisciplinary research programme on the Manica Highlands, as a social-ecological entity under global change (following, for example, the Mountain Social Ecological Observatory

Network (MtnSEON) and/or Long-Term Socio-Ecological Research (LTSER) protocols; Alessa et al., 2018; Angelstam et al., 2019), and an exhaustive quantification of its ecosystem services and the threats to these. Such research could follow approaches such the World Bank's Wealth Accounting and Valuation of Ecosystem Services (WAVES) project (World Bank Group, 2012, 2015a) and the Millennium Ecosystem Assessment for southern Africa (Biggs et al., 2004).

The existing trans-boundary relationship between Zimbabwe and Mozambique could be used as a platform to develop a holistic policy and a focused management plan for the entire Manica Highlands, based on actual research outcomes.

We hypothesise that – by improving the ecological integrity of the Manica Highlands – there will be some mitigation against the predicted increasing extremes between droughts and floods (IPCC, 2019): improved catchment integrity will potentially increase water availability in arid periods, whilst restored riparian habitats will smooth peak-flows associated with floods. Specific actions to achieve this would be likely be (1) securing the status of existing protected areas and excluding mining interests from these; (2) curbing mining activities outside protected areas to a minimum, and enforcing equitable and auditable socially and environmental 'good practice'; (3) implementing a comprehensive and long-term alien invasive species management programme, particularly against feral, high water-use species such as Pine, Gum and Wattle; (4) diversifying livelihoods away from exploitative economic activities (particularly commercial forestry and mining) to more ecologically-sustainable economic activities (for instance ecological tourism, landscape stewardship, and sustainable livestock production); (5) the enforced protection of remaining indigenous montane and riparian forest, and providing incentives for the restoration of former indigenous forest areas (through tools such as PES); and (6) encouraging local adaptation to crops more suited to local climate change (if necessary).

An overall absence of just and equitable governance is the largest hurdle to achieving sustainable development in the Manica Highlands, and has been highlighted as one of the main challenges in the SADC region (Biggs et al., 2004; Environmental Justice, 2014; National Resource Governance Institute, 2017b; Tsiko, 2017). Although Zimbabwe has been characterised over the past 20 years by 'failing institutions' – resulting in major social, economic and ecological disruption in Zimbabwe – the recent national commitment to transparent governance, tackling corruption, and improving ecological integrity (Government of Zimbabwe, 2018) offers opportunity for hope, if these can be realised at a grassroots level. While Mozambique has a better governance record than Zimbabwe over the same time period, there are still governance obstacles to achieving social and ecological sustainability in the Manica Highlands. In both countries, the greatest controversies – social and ecological – have centred on minerals, and there is an over-riding "immediate benefits" mentality regarding resources in the Manica Highlands (a phenomenon of increasing concern globally; Pavlovic, 2017; Vander Velde, 2017; Magnusson et al., 2018; Ngqakamba, 2018; Nordhaus and Huey, 2018). Researchers, civic society, policy makers and governance instruments are therefore encouraged to work closely together for a positive future for the Manica Highlands – social and ecological.

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**Conflicts of interest**

None.

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