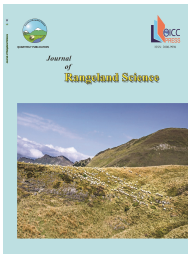

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Rangeland biodiversity: status, challenges and opportunities review

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Abstract:
Rangeland biodiversity is a multidimensional spectacle that includes the diversity of organisms, genetic differences among them and the communities, ecosystems, and landscape patterns. The variety of biodiversity life and processes is essential for moral, aesthetic and economic reasons. This review aimed to combine the earlier works on rangeland biodiversity: status, challenges and opportunities. Despite being less suited for crop cultivation, rangelands with low and variable precipitation, rocky topography, poor drainage, or harsh temperatures offer feed and water for free-ranging wild and domestic animals, as well as timber and mineral resources. Rangelands often have shallow soils, little rainfall, and slowly cycling nutrients. Habitat destruction and fragmentation, alien invasive species invasion, climate change, the incidence of accidental fire, prolonged drought, overgrazing, poor coordination among various disciplines and implementation schemes are the current critical challenges of rangeland biodiversity. Community-based management systems and participatory approaches, managing invasive species and rangeland rehabilitation, sustainable and integrated rangeland management practices, building resilience for rangeland resource dynamics, the presence of indigenous knowledge and donor support are the main opportunities for the improvement of rangeland biodiversity. Therefore, it was concluded that the current rangeland biodiversity was drastically shrinking and degrading. This suggests an urgent need for rangeland management strategies that promote biodiversity conservation.

Keywords: Biodiversity conservation; Challenges; Opportunities; Rangeland improvements

1. Introduction

Rangelands are categorized by low and unpredictable precipitation, shallow soils, rough topography and great temperatures [1]. A diverse composition of vegetation resources that predominantly involves natural grasslands, shrublands, savannas, many deserts, tundra, alpine communities, marshes and wet meadows is encompassed in rangelands [2].
The current status of rangeland biodiversity is significantly changed by the reduction in habitat, land-use changes, loss of species, unplanned fire, overgrazing, climate change and the invasion of non-native species [3–7]. There are different improvement alternatives for rangeland biodiversity from current degradation to the rehabilitation of its potential, namely building resilience for its dynamics, using a community-based management system, participatory approaches, rehabilitating and managing invasive species, sustainable and integrated rangeland biodiversity management practices [4, 7, 8].
This paper has a better role in describing rangeland biodiversity, its current status, its challenges and opportunities that give the impression of having significant effects on the sustainable management of rangeland biodiversity for further monitoring and evaluation of rangeland biodiversity. However, there is a limitation to review these ones and other related information and thereby, delivering such synthesized and summarized data to the beneficiaries.
Therefore, reviewing sensible findings on rangeland biodiversity; status, challenges and opportunities seems to be a milestone area to deliver the combined information to the beneficiaries. Based on this outlined background, the main objective of this study was: to review rangeland biodiver-

sity conservation methods, challenges and opportunities for rangeland biodiversity improvements and thereby deliver the combined information for beneficiaries. Most of the related research findings which focus on rangeland improvement, rangeland biodiversity conservation, challenges and opportunities were reviewed and combined.

2. Rangeland biodiversity

2.1 Rangeland characterization

Rangelands that have low and erratic precipitation, rough topography, poor drainage, or extreme temperatures are less suitable for crop cultivation, but they are sources of feed and water for free-ranging wild and domestic animals, as well as wood and mineral products [1]. Rangelands are typically characterized by low precipitation, shallow soils and slow nutrient cycling [9].

It consists of mainly native pastures (grass, forbs and woody plant species); they are the main feed sources of grazers and browsers [8, 10]. Major driving forces for the biological diversification of rangelands are relative aridity, seasonal patterns of rainfall, fires and herbivore pressure. A combination of these factors, coupled with topography and geology, determines the selection of pressures, resulting in the development of a variety of adaptive strategies [11]. For example, in the African savanna, humans and their livestock have left long-term legacies by creating and maintaining landscape heterogeneity [12].

Rangelands (i.e., grasslands, shrublands, savannas, hot and cold deserts, and tundra) occupy 51% of the terrestrial land surface, containing about 36% of the world's total carbon in above and below-ground biomass, which comprises a large number of economically critical species and ecotypes. It also supports approximately 50% of the world's livestock and provides feed for both domestic and wildlife populations. Across the globe, rangelands occupy almost half of the Earth's surface [9, 13, 14].

2.2 The importance of rangeland biodiversity

Biodiversity has been defined by the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) as the variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part [15]. It comprises the variety within species, between species, and ecosystems. In most commonsense, biodiversity is about genes, species and ecosystems [16].

The important ecosystem welfares which are provided by rangelands include maintaining the atmospheric composition; creating, fertilizing and stabilizing soils; moderating weather and mitigating climate change, cycling nutrients; storing and purifying water; disposing of wastes and providing natural control of diseases and pests. Loss of biodiversity can negatively influence the quality and quantity of these benefits. Conservation of rangelands is also important for maintaining ecological stability [16, 17].

2.3 International convention on rangeland biodiversity

Under the International Convention on Biodiversity (1992), signatories were required to take actions in several areas affecting rangelands: to identify the components of biodiversity important for conservation and sustainable use (article 7a), to monitor the components of biological diversity (article 7b), to identify and monitor processes and categories of activities having or likely to have significant, adverse impacts on the conservation and sustainable use of biodiversity (article 7c), to maintain and organize the data derived from the identification and monitoring activities (article 7d), to develop national strategies, plans or programs for the conservation and sustainable use of biological diversity or adapt existing strategies, plans or programs for this purpose (article 6a) and to integrate the conservation and sustainable use of biological diversity into relevant sectoral or cross-sectoral plans, programs and policies as much as possible and if appropriate (article 6b) [18].

Rangeland biodiversity (Articles 7b, 7d of the CBD) is poorly documented and is largely related to the developed economies, notably Australia and North America. In the case of rangelands, little has been achieved. Solbrig noted that no complete floral and faunal inventory exists for any tropical rangeland [19].

Despite the fact, the burdens on rangeland biodiversity (Article 7c) are well understood: intensified use of rangelands, fragmentation and loss of habitat. Still, the pressure for habitat destruction usually comes from influential groups within a particular nation-state. So, outsiders are often better placed to analyze the causes of biodiversity decline, but less in a position to take preventive actions. Governments can no longer shelter behind occupations of ignorance. Even so, progress towards archiving and maintaining rangeland resources data (Article 7d) remains slow and unconvincing. In addition, many developing countries under pressure from external donors have developed national environmental strategies; few of these include very specific provisions for rangeland protection (Article 6a), nor are these integrated with other sectorial programs (Article 6b). Where the state has taken an interest in the management and conservation of rangelands, notably in Australia, the socio-economic conditions are so distinctive as to hold few lessons for the developing world [18, 20].

3. Current status of biodiversity on rangelands

The overall biodiversity of rangelands is declining due to various factors including land-use changes and intensification, dry land fragmentation, the introduction of invasive species and mismanagement [4, 7]. Apart from the ecological aspects, the loss of biodiversity has significant implications for the food security of millions of people who depend on rangelands for their livelihood [5]. That is why rangeland management strategies that promote biodiversity conservation are urgently needed [21].

In arid and semi-arid rangelands, heavy grazing pressure and climatic factors such as elevation can influence forage production and shift composition, soil erosion and rangeland degradation and increase bush density [3, 10, 22]. Such changes would influence the productivity, sustainable utilization and management of the rangeland's ecosystem [17, 23].

A major threat to biodiversity is the reduced size of contigu-

ous habitats. Most of the world's rangelands with adequate precipitation for growing crops have been converted to crop cultivated land. In addition, irrigation using imported water or groundwater has been applied in rangeland areas. In the U.S., more than 50% of the ecosystems determined to be critically endangered are grasslands and almost 25% are shrublands [3, 5].

The rangeland that is bordering for cultivated, urban and industrial development remains less fragmented than many other ecosystems but even low levels of fragmentation may negatively affect some species and the function of some rangeland communities. Maintaining sufficient area in each type of rangeland is necessary to sustain biodiversity at all levels [3].

The rangelands are presently being extensively deteriorated both in quantity and quality [24]. Rangeland productivity hotspot needs to be protected by pastoralists to ensure the viability and growth of the pastoral production system as a whole [17, 25]. Because of worldwide climate variability and changes and exhaustive human activities, land degradation has become the most serious problem in modern society, particularly in the ecologically sensitive arid and semi-arid areas [6].

Rangeland degradation and fragmentation imply a reduction in status, which includes a vegetation composition change or a transition from one organic form to another organic form, a loss of top soil and a continuous reduction of productivity/biomass of the ecosystem. Niguse and Gizachew generally indicated that lower biological diversity is supposed to occur in degraded rangeland [6].

Grazing is an important process in many rangeland ecosystems and it has both positive and negative impacts on biodiversity at all levels. Uninterrupted heavy animal grazing and trampling can adversely affect some rare plant species populations. Several species are jeopardized by activities related to livestock grazing management including the grizzly bear, Mexican wolf and black-footed ferret [26, 27]. On the other hand, some rare species are favored by grazing. For example, the mountain plover nests only in heavily grazed short-grass steppe ecosystems.

Moderate grazing and trampling usually increase the diversity of plants by decreasing the ability of any plant species to become dominant and exclude other species. However, continuous grazing highly influences the diversity of the community by eating the selected plant species and trampling on them. Optimum grazing can create gaps in the plant community, making light, moisture and nutrients more available. Grazing intensity, the evolutionary history of the site and climate are the determinants of the diversified plant community. If grazing is excluded, the number of species may increase in the short term but may decline in the long term because the system itself changes. It may develop into a system that is less able to withstand other disturbances, such as drought and fire. A combination of grazing and prescribed burning is used by rangeland professionals to improve landscape diversity by creating patterns of different communities. In addition, large tracts of land owned or managed by livestock operators can assist in protecting biodiversity by maintaining contiguous habitats [3].

The expansion of non-native species invasion is increasing the threat to rangeland biodiversity, which can cause many facets of biodiversity to change. For example, as cheatgrass from Eurasia become a more common component of the sagebrush steppe ecosystem, the nutritional quality of available forage was reduced, the intensity and frequency of fires changed and the water cycles of these ecosystems were altered. Several native animals, the sage grouse, in particular, have declined because of these changes [3, 5, 6].

4. Rangeland biodiversity conservation methods

4.1 Habitat restoration

Habitat conversion and the resulting fragmentation are probably the most severe causes of declining biodiversity in rangelands; the most immediate response has been restoration. Habitat restoration is analogous to the recovery of threatened and endangered species but at a broader ecosystem or landscape level. Techniques such as the reconnection of hydrological connections within wetlands, the reintroduction of lost species, the burning of invasive vegetation, the introduction of livestock grazing systems compatible with wildlife, fencing to exclude cattle, vegetation planting to control erosion, fertilization of existing vegetation to encourage growth, control of exotics and others can be used to restore ecosystems. Such strategies are costly and can only be implimented on a limited scale, even in the developed world. Moreover, they depend on the assumption of a value-free model of the pre-existing ecology and an argument about why this should be restored [20].

4.2 Keystone' species and the assignation of priorities

Rangeland biodiversity conservation usually emphasizes threatened and endangered species. They are the most fragile and potentially vulnerable members of biological communities and may be indicators of environmental disturbance [28]. However, not all threatened and endangered species can or should be conserved. Extinction is a part of the evolutionary process, and policies that place equal emphasis on every species are both ecologically unsound and tactically unachievable [20, 29].

Priorities must be assigned to different species, conservation programs tend to emphasize those which are large, generally easily observable, or aesthetically attractive. Conservation (emergency) programs of the type //save the elephants in western Kongo// are often uncoupled from scientific understanding and focused on satisfying the opinions of those who watch the National Geographic channel. Regularly, such programs tend to address indicators rather than underlying causes, although priorities should not be based on constructed public images but scientific understanding. Key species are defined in terms of their greater influence on the functioning of ecosystems. For West, "keystone" species are those whose direct or indirect effects on the survival of other species or ecosystem function are disproportionately large in relation to their abundance [29]. For instance, mycorrhizal fungi species are the organisms that are used to exchange carbon fixed by green plants for enhanced uptake of phosphorus and their absence may severely inhibit the

recovery of about 90% of the green plants that interact with them.

Repeated fires promoted by cheatgrass in the former sagebrush steppe (US) can lead to the extinction of mycorrhizae and impede the re-establishment of shrubs and perennial grasses over large areas. Keystone species can also be small mammals. An experiment in the Chihuahuan-Sonoran Desert in Arizona showed that without kangaroo rats, a shrub-steppe quickly changed to grassland as the digging of these rodents favors the establishment of shrub seedlings. Without them, grass competitively squeezes out shrubs [6, 20, 28, 29].

4.3 Establishing protected areas and managing to overgraze

The establishment of protected areas is a primary strategy to conserve biodiversity, although reserves alone cannot guarantee that biodiversity will be maintained [20]. Artificial water sources are now widespread in many arid and semi-arid rangelands. For example, in pastoral areas of Australia today, there is at least one artificial water point every 10 km [26].

Originally, establishing closely spaced water sources was intended to avoid the localized degradation that follows the concentration of many animals at a few sites. Creating this dense network induced similar grazing patterns over large areas. The impact on biodiversity was negative because native species in Australia's arid and semi-arid rangelands are adapted to very light or no grazing pressure. When rangeland biodiversity becomes a consideration, management should improve grazing patterns that are spatially diverse rather than unchanging. Fencing tends to be expensive for extensive areas, whereas water is a powerful and cheap tool for this purpose. Such a strategy is only applicable where artificial water sources are numerous and would not apply in Africa or much of South America [20, 26].

5. Challenges of rangeland biodiversity

Rangeland biodiversity presently faces both area reduction and degradation (productivity reduction). The extreme change in biodiversity can be observed among seasons within a year and between years and decades. There are different factors that are affecting the rangeland biodiversity, such as overgrazing, unplanned fire, invasive plants, weather and climate and fragmentation [25, 30, 31].

5.1 Habitat destruction and fragmentation

Loss of biodiversity is a worldwide concern; one primary cause is habitat destruction and fragmentation [32]. The destruction of habitat is the process in which ordinary habitat is unable to support the species present. This scenario easily displaces or destroys and reduces the biodiversity of organisms that previously used the site. The expansion of agriculture is the principal cause of habitat destruction. Besides this, the rate of destruction might be accelerated due to other causes like climate change, invasion by alien species, overexploitation and extinction cascades [33–35]. Other important causes are the development of industry, mining, logging, trawling and urban sprawl [36].

Population growth is associated with an increase in resource consumption, which causes expansion and intensification of land use, over utilization of biological resources, exploitation of marginal lands and the breakdown of traditional resource-management systems [37]. The continuous increment of human populations and the growth of per capita consumption have resulted in unmanageable exploitation of biological diversity, aggravated by climate change and other anthropogenic environmental impacts [38].

Fragmentation of rangelands is also another challenge due to rapid population growth. Throughout the world, fragmentation is one of the most critical threats to biodiversity and ecosystem services [39]. An increase in the human population in rural areas has resulted in the extreme fragmentation of rangelands in many areas. Paramount rangelands are plowed and converted to crop-cultivated land, thereby destroying the protective plant cover. The same environmental features that make the land attractive to wildlife, such as gentle slopes, proximity to streams and timbered draws, also make the land appealing to developers and people who want to build [6, 33].

5.2 Alien invasive species invasion

Next to habitat destruction and fragmentation, invasive alien species are among the world's most significant threats to indigenous rangeland biodiversity, their introduction and establishment will ultimately lead to a severe leveling off of biodiversity. The major impacts of invasive species include disruption of the general ecology of an ecosystem, changing the fire regime, water and nutrient cycling and affecting the biogeochemical processes of landscapes. These species are increasingly spreading both in natural and non-natural systems [40].

Alien invasive species cause biodiversity loss by competing with native species for feed and habitat and altering the physical environment in a way that excludes native species. Exotic invasive species often live together with native species for a prolonged time and progressively become outward as their population grows larger and denser because of their superior competitive ability. Invasive species are the most serious threats to the health and sustainability of rangeland ecosystems. For instance, parthenium (Kiliginoole) species and Latana camara (in the rangeland of the Ethiopian Somali region), Prosopis juliflora (Woyane tree or Girawaa) in Afar rangeland [23].

Other identified impacts are bush encroachment (Boran rangelands of Oromia region, Ethiopia) in both rangeland and forest areas, as well as changes in tree-grass interactions, increased use of land for cultivation, ban on the use of fire and development of water ponds, which are the main challenges for Ethiopian rangeland resources [5, 6, 41]. The other emerging plant invaders, such as Cryptostegia grandiflora, Parkinsonia aculeata, Mimosa diplorotricha and Nicotiana glauca are also reported by Rezene et al. [42].

5.3 Impact of climate change and variability on rangeland biodiversity

Climate change and variability are likely to impact rangelands in a variety of ways, with critical implications for local livelihoods as well as for areas and communities that

they may depend on. Climate change is progressively being recognized as a global crisis threatening human survival and biological resources. There is aggregate evidence that climate change, particularly increasing temperatures, is already having significant impacts on the world's physical, biological and human systems and it is expected that these impacts will become more severe in the future [43–46].
The report of Joel et al. indicated that temperature increases are likely to result in changes to tree lines and phenology for certain species [47]. Moreover, the implication of increased temperatures for pests and pathogens affecting key species in both natural and plantation rangelands is a key area of concern. Climate change is thus likely to change grass-tree interactions (not simply through increased carbon dioxide), thus altering the balance between wooded areas and rangelands, albeit building on an already dynamic base [27].
According to the early reports of Loibooki et al., the impacts of climate change on biodiversity may be manifested indirectly through exacerbating other factors or agents contributing to the loss of biodiversity [48]. The factors include poverty, which may force the victims to adopt coping strategies that are destructive to biodiversity, involving illegal hunting, encroachment, wildfire, human-wildlife conflicts, soil erosion and siltation of water bodies that may increase the eutrophication of lakes, thereby impacting aquatic and terrestrial wildlife negatively. Climate change may also increase the spread of invasive species and is a key ecological driver that influences the dynamics of sub-Saharan rangelands [49].
The impacts of climate change can vary widely across the universe, but in the developing countries, many of them in Africa are generally considered more vulnerable than developed countries due to their poor adaptability. Poor people are particularly vulnerable, and population growth is an additional challenge, increasing pressure on natural resources and poverty. Rising global mean temperatures above the $1.5 - 2.5$ °C range can lead to major changes in ecosystem structure, function, and geographic range, which can adversely affect species distribution and survival [50].

5.4 Incidence of accidental fire

There is no fire policy in existence and fire issues are dealt with on an ad-hoc basis by individual ministerial sectors, particularly in the ministries responsible for managing natural resources (wildlife, forests and livestock). A fire rapidly converts the dead and decadent plants into inorganic ash that contains nutrients and minerals for new plant growth. However, if fires are too frequent or intense, organic matter at the soil surface and plant cover can be reduced. The occurrence of an unplanned fire almost always results in a loss of nutrients through volatilization, oxidation, ash transport, and erosion [41, 51].
An increased intensity of the fire is likely to favour grass production, while a reduction in fire intensity may favour tree production. Considering Acacia mellifera encroachment, some studies in the World report that fire may act as the critical mediator of transitions from open savannah to thicket [52].

5.5 Prolonged drought and overgrazing

Prolonged drought in many parts of Africa's lowlands is a prominent factor that has contributed to range degradation. Herlocker noted that the occurrence of drought and overgrazing together can have a double impact on the productivity of the rangelands. Extended drought, including a shortage and erratic rainfall, can cause serious range degradation [53, 54].
Overgrazing is also another factor of rangeland degradation; the most palatable species are not given enough rest to survive and invader plants are developing. When overgrazing is combined with recurrent droughts, it also leads to perennial species reduction. All these phenomena are exacerbated by changes in pastoral systems such as the decrease in mobility and the introduction of mechanization to transport livestock, livestock feed and water [6, 41].

5.6 Poor coordination among various disciplines

The government and non-government had invested huge sums of public money in setting up the institutional framework for the national agricultural research, education, and extension systems, there seem to be no strong functional linkages among them [55]. Poor coordination among educational institutes, research centers, extension and other concerned stakeholders has a tremendous effect on formal technology development and the transfer of technologies from researchers to local experts and local communities. The concept of linkage implies the communication and working relationship established between two or more organizations pursuing commonly shared objectives to have regular contact and improve productivity [56].

5.7 Implementation and policy challenges

Different countries have been designed with several important policies and strategies related to the environment. Conversely, setting appropriate policies and strategies is not an end in itself. The goals stated in the different policies can only be achieved if and only if that policy is properly implemented. Although the poor implementation of policies and strategies remains a major constraint, some other policies and strategies are hindering the proper implementation of effective and sustainable practices for rangeland biodiversity management [57, 58]. In developing countries, policies are generally based on political considerations and economic benefits, so strengthening the political representation of local pastoral communities will also transfer the benefits of development projects to local pastoral people.

6. Opportunities for rangeland biodiversity improvement

6.1 Community-Based management systems and participatory

Community-owned and managed conservancies present an opportunity for the intersection of development goals and biodiversity conservation in rangelands. Participatory approaches have no doubt allowed rural development and research workers to put farmers first in needed analysis and come up with point solutions [8]. It is important to

contribute to the sustainable development of rangeland resources by encouraging local innovation and participation of all concerned bodies.
It is highly appropriate to utilize the existing natural resource management networks when drafting policies and strategies to gain a better understanding of the aspirations and inherent rights of customary owner groups and to engage local communities in the rangelands. Thus, a community-based management system is essential for the rangeland resources, i.e., indigenous communities in the rangelands currently have full ownership and some management responsibilities for the rangelands [59, 60].

6.2 Managing invasive species and rangeland rehabilitations rehabilitation

Managing and controlling the invasion of bush encroachment and other invasive species is a highly good option for rangeland resources improvement in rangeland resource [5]. On arid and semi-arid grasslands, technical interventions such as reseeding and fertilizer applications are constrained by the risk of failure and expense, with the limited potential for financial returns [3, 6].

6.3 Sustainable and integrated rangeland biodiversity management practices

According to the Society for Range Management, specific strategies for sustainable rangeland management include things like prescribed grazing on rangeland and developing a grazing management plan on rangeland resources [8]. Progress towards the achievement of the sustainable rangeland management system requires an adaptive and integrated approach to the decision-making process [8, 25].
Integrated rangeland management is critical for the improvement and sustainable maintenance of the natural resource and for fostering efficient and sustainable ecosystem dynamics. Integrated rangeland management promotes humans to work in a group for collective actions and seeks to set the boundaries and improve the legal and institutional systems for creating appropriate decision-making and promoting resource stewardship [27].

6.4 Building resilience for rangeland resource dynamics

Resilience in this sense has been described as the capacity to continually change, adapt and transform through innovation in response to external drivers and internal processes [61]. The report by Lee reflected that building resilience in the rangelands would be critical to adapting to short-term and long-term changes such as seasonal conditions and climate change [8].

6.5 The presence of indigenous knowledge and donor support

Local communities are rich in indigenous knowledge and practices that can promote and enrich rangeland biodiversity and sustainable utilization. According to Pender et al. report, there are several donors and development partners interested in assisting the interventions for improving land resource management [57].

7. Conclusion

Rangeland is a type of land that encompasses a diverse composition of vegetation resources, predominantly natural grasslands, shrublands, savannas, many deserts, tundra, alpine communities, marshes and wet meadows. The overall biodiversity of rangelands is declining due to various factors, including land-use changes and intensification, dry land fragmentation, the introduction of invasive species and mismanagement. Rangeland biodiversity can be conserved through establishing protected areas, habitat restoration, keystone species and the assignation of priorities and controlling grazing pressure.
There are different challenges to rangeland biodiversity, such as habitat destruction and fragmentation, climate change, invasion of exotic species, the occurrence of unplanned fire, overgrazing and recurrent drought, poor coordination among various disciplines and policy and implementation strategies. However, there are different opportunities for rangeland biodiversity improvement, like building resilience for rangeland biodiversity dynamics, participatory and community-based management systems, rangeland rehabilitation and managing invasive species and sustainable and integrated rangeland management practices. Therefore, the following recommendations are suggested for the improvement of rangeland biodiversity based on the conclusions of the current review:
• Habitat restoration and plant species adapted rangeland will need to be identified and developed.
• Biodiversity conservation efforts are being focused on using the collective knowledge of rangeland science and management.
• The best way to minimize species loss is to maintain ecosystem integrity across landscapes by placing a priority on maintaining soils and ecosystem functions. Without these features, the overall potential for all biodiversity will be seriously diminished.
• Effective law enforcement is needed as a basic foundation of any conservation strategy and
• Pastoralists and local people shall be encouraged to manage rangeland biodiversity.

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