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Review Article

Rangelands Biodiversity Conservation and Management

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ABSTRACT

Biodiversity is a term given to the variety of life on earth and the natural patterns it forms. It often classified at three levels, which are genetic diversity, species diversity and ecosystem diversity. Genetic diversity represents the heritable variation within and between populations of organisms. Species diversity is measured by the total number of species in a given study area. Ecosystem diversity refers the variety of different habitats. Evidence shows that, there is a highly complex relationship between species and ecosystem diversities. Rangelands are characterized by a high biodiversity, which is economically important both locally and nationally. Apart from this role, rangelands serve for a number of functions such as ecological, ethical and the protection of gene pool. Rangelands are sources of forage/fodder for about 360 million cattle and over 600 million sheep and goats for an estimated 100 million people in arid areas. Eastern Africa rangelands harbor a rich agro biodiversity of cultivated food crops and their wild relatives, which contribute to crop improvement programs and food security. Thus, in order to sustain the benefits of biodiversity, conservation is needed at all levels. Rangelands can be used sustainably if their ecosystems are maintained intact and they are most productive when their components are put to a variety of uses. There are two main conservation methods, which are currently practiced in some of the eastern African rangelands: Ex-situ conservation in form of gene bank or germplasm management, in vitro storage and field gene banks are commonly used. Another method is in situ conservation, which include protected areas and home gardens. However, such conservation efforts are affected by rapid population growth, poor government policies, sedentarization, breakdown of traditional institutions and resource utilization and rangeland degradation which serve as major causes of genetic erosion in rangelands of eastern Africa. The eastern African indigenous knowledge in management of rangeland biodiversity involves several techniques. Pastoralists have over many generation developed communal tenure and land use practices; and they also have their own herd management and water management practices which help them to successfully use the rangelands on sustainable basis. Such practices can and should play an important role in maintaining rangeland biodiversity, especially when blended with more modern scientific rangeland conservation and management practices. Improved scientific understanding of biodiversity, notably its role in ecosystem functioning, is a precondition for increased concern and thus action to conserve it.

Key words: Biodiversity conservation, Rangelands, Genetic erosion, Conservation methods

INTRODUCTION

Biodiversity is a term given to the variety of life on earth and the natural patterns it forms (McNeely, 1998) has defined biodiversity as an umbrella term for the degree of nature's variety, including both the number and frequency of ecosystems, species and genes in a given assemblage. The biodiversity we see today is the fruit of billions of years of evolution, shaped by natural processes and increasingly by the influence of humans. Diversity is often understood in terms of the wide variety of plants, animals and microorganisms and the ecological role they play and the genetic diversity they contain. So far, 1.7 million species have been identified worldwide (WCMC, 1992). Studies on species diversity indicated that, most of the natural habitats are incomplete, our understanding on the number of species present in each habitat type is fragmentary, particularly so with lower taxa (UNEP, 1995). According to many of the biologists in the world, biodiversity is defined at three levels i.e. genetic diversity, species diversity and ecosystem diversity (Herlocker, 1999; UNEP, 1995).

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Genetic diversity refers to the variety of genes. It is, therefore a measure of variability both within and between species. According to Herlocker, (1999), genetic diversity represents the heritable variation within and between populations of organisms. Genetic diversity is particularly important for agricultural productivity and development (FAO, 1996). The genetic materials, which are of potential economic, scientific and/or socio-cultural value is defined as genetic resources (Attere *et al*., 1991). Species diversity refers to the variety of living organisms on earth, and is measured by the total number of species in a given study area, habitat or ecosystem (Herlocker, 1999). The species level is generally regarded as the most natural at which to consider whole organism diversity (UNEP, 1995). Due to the fact that species are also the primary focus of evolutionary mechanisms, and the origination and the extinction of species are the principal agents in governing biological diversity. The ecological importance of a species is that it can have direct effect on community structure and thus on overall biodiversity. An ecosystem diversity refers to the variety of different types of habitats, thereby components of one habitat may also represent in the nearby habitat thus making intensive interactions between each other. Diversity of ecosystem is often assessed in terms of the diversity of species (UNEP, 1995), which may include evaluation of their relative abundance.

Evidence shows that, there is a highly complex relationship between species and ecosystem diversities and that this relationship is due to the inherent interdependence (Herlocker, 1999). Genetic diversity can be maintained only if the size of the breeding population of the species is kept above the minimum critical level (Herlocker, 1999). Subsequently, the maintenance of this viable population requires the maintenance of a sizable habitat to support it, which in turn requires the continued survival of larger ecosystems. Conversely, ecosystems are what they are because of species that compose them and the manner in which they interact with the abiotic factors (Herlocker, 1999). The relationship between biodiversity and humans' wellbeing is vital. Man extract his direct needs such as food, medicine, fiber etc, from plant and animals which are part of biodiversity and which are dependent on other species and ecosystems for their existence (Herlocker, 1999; UNEP, 1995). Ecosystems on the other hand, provide humans with valuable services which include the maintenance of air and water quality, amelioration of climates and the development of soils (West, 1995). Thus in order to sustain these benefits, biodiversity conservation is needed at all levels.

Why conserve biodiversity of rangelands

Rangelands dominated by grass and grass like species with or without scattered woody plants, occupying between 18-23% of world land area (Blench and Sommer, 1999). They are home both to significant concentration of large mammals and plants with a high value in both leisure and scientific terms and to humans that have historically been excluded and marginalized like: pastoralists and hunter-gatherers (Blench and Sommer, 1999). Rangelands present a paradox for the conservation ethic; however, most are definitely not "natural" and very often prove to be recent formations. Arguments for the conservation of biodiversity in rangelands are a subset of those for biodiversity in general (Blench, 1998). Rangelands can be sustainable if their ecosystems are maintained intact and are most productive (Blench and Sommer, 1999); assuming they are put to a variety of uses. But the tendency has been both to turn individual ranges to single uses and to try and extract the maximum value over a short period. Indeed the argument must be turned on its head; there is a strong case, on both economic and ecological grounds for thinking that rangelands should be a place for diverse species to fulfill their intended function over the longer term (Blench and Sommer, 1999).

Economic role of rangelands

The fact that eastern African rangelands are home for a diverse species of plants and animals makes them important economically to local communities as well as at national level. Economic arguments for biodiversity conservation in rangelands may be said to have direct and indirect elements; for example loss of large mammals or indiscriminate burning can result in reduced tourism revenue of the country while replacement of grass species can reduce soil fertility and quality, contributing less to ecosystem services (Alemayehu, 2004). The diverse nature of plants and animals in the rangelands are primarily sources of forage/fodder, fuel wood, fiber, dyes, resins, medicines and food. Elmi (1983), stats that there are many traditional medicinal value in Somalia. Rangelands also contribute significantly to national economies within Eastern Africa. For example, they are a major support of tourism; and the major eastern Africa national parks such as the Serengeti and Ngorongoro in Tanzania, the Tsavo and Amboseli in Kenya and Qeenelizabert in Uganda occur within rangeland ecosystems.

Economists argue that some loss of biodiversity is an inevitable and justifiable cost of economic development (Flint, 1992). Conventional economic approaches to assess how much biodiversity should be conserved are hampered by inadequate scientific information and the nature of biodiversity. Markets give no signals of rapidly declining biodiversity, because they do not capture its value. Defining a critical threshold under which biodiversity should not be depleted is nearly impossible with current scientific knowledge. Current policies and market forces will result in further loss of biodiversity, thereby transferring an accumulation of risk to future generation (Flint, 1992). The economic perspective on biodiversity decline is not limited to the direct costs of species extinction. Changes in the mix of species modify the ecosystem over the long term. For instance, a shift in the vegetation composition from palatable grasses to unpalatable grasses and woody plants reduces the availability of forage/fodder for livestock. Woody vegetation can sometimes become so thick as to prevent livestock access completely, but in more open landscapes, it tends to attract pastoralists specialized in browse species. Low income groups whose livelihoods depend heavily on rangeland production are particularly affected.

Ecological role of rangelands

Rangeland ecosystems provide "natural" services such as fertility of soils, water cycling, biomass production, cycling of nutrients and natural control of pathogens and parasites. This contributes to ecological stability. Rangeland ecological stability is related to the amount and composition of the vegetation cover and animal species in the area. Vegetation cover provides stable rangeland ecosystems, which expedite nutrient recycling and protection with the balance of organisms leads to long-term declines in biodiversity and lowered capacity to respond to extreme events such as fire and drought (Blench and Sommer, 1999). Genetic diversity also provides a natural barrier against the evolution and spread of pathogens that can result in large scale forage or food deficits. As a rule, the more genetically uniform a population is, the more vulnerable it is to pathogens. Plants and animals constantly adapt to counter such assaults. The more diverse a population is, the greater the chance of developing strategies against these pathogens (Blench, 1998). Thus, extinction of rangeland plant species and the ecosystems they inhabit should be avoided for reasons of ethics, present self-interest and perpetuation of our biological heritage for the benefit of future generations.

Ethical and aesthetic role of rangelands

Diversity has a value in itself, that organisms are attractive in their own right (Blench and Sommer, 1999). This is linked to the "stewardship" argument, that we have an ethical responsibility to preserve biodiversity for future generations, partly because the function of so much biodiversity remains unknown and it would be irresponsible to destroy a resources whose potential has remained unexplored. Most of the plant species in eastern Africa's rangelands are well adapted to diverse conditions and for this reason are important sources of genes that confer drought tolerance and disease resistance in new varieties of forage and crop improvement program. It is not possible to predict what species may be extremely useful in the future. Many species, which seem dispensable and of very little value today may become useful in the future (Herlocker, 1999).

Rangelands biodiversity

Overall biodiversity

Biodiversity is often taken to refer mainly to the diversity of species, especially where conservation is under discussion. Species diversity still receives more attention and is better understood than genetic or ecosystem diversity (West, 1995). But species both exist within a larger matrix of ecosystem and landscape are themselves composed of genetic elements that may vary in patterns distinct from the species itself. Biodiversity must then encompass the variety of living organisms, the genetic differences among them and the ecological processes and landscapes in which they occur. in eastern Africa however, the biodiversity of rangelands in ecosystem term is poorly described in relation to their overall importance (Blench and Sommer, 1999). Eastern Africa comprises of Kenya, Tanzania and Uganda as well as Ethiopia, Somalia, Eritrea and Djibouti. Rangelands which are defined by Herlocker (1989) as uncultivated land that will support grazing or browsing animals, occur extensively throughout the region; Somalia, Djibouti and Eritrea are almost entirely rangeland. Eastern Africa rangelands cover a large area of land; 88% of Kenya, 83% of Tanzania, 40% of Uganda, 56% of Ethiopia and almost all of Somalia, Eritrea and Djibouti (Hopkins and Jones, 1983; Herlocker *et al*., 1997). Rangelands provide forage/fodder for about 360 million cattle and over 600 million sheep and goats and some 9% of the world's beef and 30% the sheep and goat meat. For an estimated 100 million people in arid areas, and probably a similar number in other zones, livestock production is the only possible source of livelihood (De Haan *et al*., 1997). The rangelands of Eastern Africa harbor a large number of plants species.

Agro-biodiversity

Although the term "agricultural biodiversity" is relatively new- it has come into wide use in recent years as evidenced by bibliographic references- the concept itself is quite old (Deurloo *et al*., 1998). Agricultural biodiversity is a vital sub-set of biodiversity. It is a creation of humankind whose food and livelihood security depend on the sustained management of those diverse biological resources that are important for food and agriculture. Deurloo *et al*., (1998) states that, agro-biodiversity includes: harvested crop varieties, livestock breed, fish species and non domesticated (wild) resources within field, forest, rangeland and in aquatic ecosystems: non harvested species within production ecosystems that support food provision. Agricultural biodiversity encompasses the variety and variability of animals, plants and micro-organisms which are necessary to sustain key functions of the agro-ecosystems, its structure and process for and in support of food production and food security (FAO, 1999). It is not only the result of human activity but human life is dependent on it not just for the immediate provision of food and other goods but for the maintenance of areas of land that will sustain production and for the maintenance of the wider environment.

According to FAO (1999), agro-ecosystem comprise polycultures, monocultures, and mixed systems, including crop-livestock systems (rice-fish), agro-forestry, agro-silvo-pastoral systems, aquaculture as well as rangelands, pasture and fallow lands. Their interactions with human activities including socio-economic activity and socio-cultural diversity are dominant. Some of the key functions for maintaining stable, robust, productive and sustainable agro-ecosystems may include the following: breakdown of organic matter and recycling of nutrients to maintain soil fertility and sustain plant and consequently animal growth; breakdown of pollutants and maintenance of a clean and healthy atmosphere, moderation of climatic effects such as maintaining rainfall patterns and modulation of the water cycle and the absorption of solar energy by the land and its subsequent release; maintenance and stability of productive vegetative, fish and animal population and the limitation of invasion by harmful or less useful species, protection and conservation of soil and water resources. The Ethiopia center of genetic diversity provides the greatest number of genetically related relatives which include finger millet, sorghum, lentil, faba bean, chick pea and field pea (Engels and

Hawkes, 1991). Farmers value and maintain diversity for many reasons. Traditional systems often include cash crops as well as subsistence crops in a diverse mix. The methods of agro biodiversity conservation evolve, adapt and persist today. The linkage with markets and systems is also influential and important to consider in affecting agro-diversity. Agro-diversity threatened and destroyed by several major factors and processes. Among these, the main ones include: policies and programs promoting monoculture agriculture technology packages that creates obligations to farmers to stop using diverse and traditional varieties; population growth and movements; inadequate institutional capacities and weak legal systems to protect lack of awareness of the value of agro-biodiversity and under valuation of local knowledge; inadequate measures of productivity; lack of policy incentives for agro-biodiversity conservation and conflicts and political turmoil.

Economic value of rangeland biodiversity

The economic importance of rangelands worldwide is extremely variable according to the socio-economic system in which they are embedded (Blench and Sommer, 1999). In Africa and especially eastern Africa, rangelands are essential to the subsistence of pastoralists, foragers and farmers dependent on rain fed crops (Blench and Sommer, 1999). Such groups are generally the most vulnerable groups in the region, both because they depend on a variable climate to support a necessarily patchy resources and because tenurial regimes tend to be more ambiguous in regions often regarded as a common pool resource. The consequence of this is that there is a sort of gradient of competition for access to rangelands. Eastern Africa rangelands are very diverse in plant species. Mbuya *et al*., (1994) lists at least 230 species of trees and shrubs with multiple uses. Plants contribute significantly to the subsistence and general economy of rural populations. They are important sources of food, fodder, fuel wood, timber, building materials, medicine, fibers, gums, dyes, resins and handcrafts (Herlocker, 1999). This significance of plants varies from place to place and from one community to another.

Multiple use of rangeland plant species

An example of plants that are used for multiple uses include the baobab that occurs primarily in Tanzania, eastern Kenya, southern Somalia and the far west of Ethiopia and Eritrea. Baobab trees are economically, medicinally, and culturally important and almost all parts of the tree are important in different ways (Herlocker, 1999). Another important tree plant is *Acacia senegal*, which is mostly abundant in southern Tanzania (GoT, 1998) and is the main source of gum Arabic. This product is used as stabilizer in food and paper industries in northeastern Kenya and Sudan (Herlocker, 1999). Gum Arabic is also edible and in addition its pods and leaves are used as forage/fodder for animals. Also, the leaves, bark and gum are used to treat diarrhea, hemorrhage, opthalmia and colds. Moreover, the tree is also a source of fuel wood, fiber and grown as ornamental and windbreak.

Some important plant uses

Forage/fodder

Forage/fodder is one of the economical uses of rangeland plants of eastern Africa. Forage/fodder plants include trees, shrubs, grasses and forbs, which provide forage/fodder for both domesticated and wild animals. According to Herlocker (1999), 78% of all woody and herbaceous plants are useful as fodder. In mixed crop livestock systems, forage legumes play a central role. They provide high quality feed for livestock and help improve soil fertility and boost crop yields (ILCA, 1978). Although, eastern Africa rangelands are rich in forage/fodder plant species, inadequate nutrition is one of the most serious constraints to livestock production (ILCA, 1978). The area faces: great scarcity of adapted high yielding forages; insufficient knowledge of the effects of nutrients and water limitations and plant performance; the absence of effective herbage seed supplies; inadequate use of biological pathways for effective supply and use of nutrients; inadequate knowledge of the characteristics of plant continents that affect plant nutritive value and inappropriate integration of advanced feed material into mixed production systems (ILCA, 1978). The underfed animals are unable to fulfill their genetic potential. Thus, improvement of forage production and feeding systems is a key element in range management.

Food

Many rangeland plant species serve as food sources and therefore they help to alleviate problems of food availability and malnutrition in these areas (Herlocker, 1999). Examples of plant species that serve as food sources are *Balanites aegyptica*, *Acacia seyal*, the leaves of which are edible; *Cucumbita spp*., and *Citrullus spp*., which are used as vegetables. Mbuya *et al*., (1994) has reported 89 trees and shrubs species, which are used in Tanzania and other eastern African countries such as Ethiopia, Eritrea and Djibouti for food. The nut of the yeheb (*Courdeauxia edulits*), which is native in Somalia, eastern Ethiopia and Djibouti, is regarded as a highly nutritious food plant (Herlocker, 1999).

Table 1: Some multiple use tree and shrub species

Uses	*Balanites aegyptica*	*Acacia toltilis*	*Sclerocarrya birrea*	*Tamarindus indica*	*Zizyphus mauritiana*
Fuel wood	u	u	u	U	U
Timber	u	u	u	U	U
Poles	u	u	-	-	U
Fodder	-	u	u	U	U
N_2 fixation	-	u	-	-	-
Medicine	u	-	u	U	-
Food	u	u	u	-	-

Source: Herlocker, 1999; u= useful.

Medicine

Medicine is another economic importance offered by rangeland plant species. Among the most reported plant species with numerous medicinal uses is *Balanites aegyptica*, the parts of which contain a saponin (a molluscide) and kills Cyclops flea, which is the host of Guineaworm (IPGRI, 2003). This plant is also used to treat coughs, snakebite, jaundice, yellow fever and syphilis. Almost all acacia species have medicinal value particularly *Acacia seyal* and *Acacia nilotica*, which are used to cure hemorrhage and diarrhea. Other medicinal plant species include *Dichrostachys cinerea*, the bark of which is used to make anthelmintic, *Teclea nobitis*, *Aloe macrocarpa*, *Papea capensis* and *Commiphora Africana* (Herlocker, 1999). In addition to their value of traditional medicine, the potential of rangeland plant species for production of conventional medicines is immense.

Timber and domestic economy

Rangeland trees and shrubs are widely used by rural populations for timber and income generation (Wickens, 1980). There are three major categories of uses, which are pole timber for building frames etc, timber for local domestic use, such as doors, furniture and boxes, and commercial timber for various uses. Some species can be put to multiple uses. For example, *Acacia albida* can be used to make oil presses, mortars, drums, boats, dugout canoes, furniture, joinery, interior fittings, boxes, benches, structural materials and saddles. *Combretum* and *Terminalta spp.*, provide hardwood for building frames, etc, timber for local domestic use, such as doors, furniture and boxes, and commercial timber for various uses. Combretum and *Terminalia spp.*, provide for building timber, beehives, tool hardwood trees is *Dalbergia melanoxylon* (black ebony), especially in Kenya and Tanzania (IUCN, 1996).

Conservation methods

***Ex-situ* conservation**

Ex-situ conservation is the conservation of components of biological diversity outside of their natural habitats. *Ex-situ* conservation has long been used as the primary method for the conservation of plant genetic resources. It is generally used for the purpose of safeguarding species that are at risk of destruction, replacement or genetic deterioration. Moreover, it is also used for other purposes including the production of material for reintroduction, reinforcement, habitat restoration and research (Herlocker, 1999).

Gene bank/ germplasm management

There are several technologies for the *ex-situ* conservation of plant genetic resources but most of them are stored as seeds in gene banks. This involves drying seeds; packing them in air tight containers and storing them at sub zero temperatures in cold stores or deep freezers (Herlocker, 1999). Endangered plants may be preserved in part through seed banks or germplasm banks. Endangered animal species are preserved using similar techniques. Gene banks help keep plant genetic diversity safe, genetically stable and accessible to users. But for conservation to the effective, good gene bank and germplasm management practices are essential. The *ex-situ* conservation of germplasm gives rise to several problems relating to the management of accessions and the maintenance of genetic integrity; for example, in the area of regeneration. The ability to move and sore germplasm safely is another important aspect of germplasm management. In order to increase the accessibility, ensuring the proper documentation of collections is an important aspect. Germplasm data must be organized and analyzed in order to be accessible and meaningful to potential users. Now that botanic garden are increasing their conservation responsibilities. Some have introduced gene banks into their gardens. Ensuring proper management practices will be a priority.

***In-vitro* storage**

For plants that cannot be preserved in seed banks, the only other option for preserving germplasm is *in-vitro* storage, where cuttings of plants are kept under strict condition in glass tubes and vessels. The main equipment includes lamina flow cabinets, autoclaves, precision weighing, balances and growth chambers with controlled environmental conditions (IPGRI, 2003) provide a good account of the design and establishment of *in-vitro* gene banks.

Field gene banks

Other technologies exist for the *ex-situ* conservation of these species such as field gene banks and crop reservation. This form of conservation is quite commendable for active collection but it is unsuitable for long-term conservation. Field gene banks can be fruit tree orchards, clone archives, artificial plantation of rangeland species, seed stands or provenance collection, arboreta and botanic gardens.

Botanical gardens

Botanic gardens have traditionally maintained their plant material as living collections in the garden, a method that has consequently been regarded as an *ex-situ* approach. Eastern Africa has 10 botanic gardens, which contain a total of 4,130 accessions in cultivation (Table 2). The establishment of seed banks has more recently complemented this, conserving plant genetic resources requires not only about finding the most appropriate and effective technology but also proper management and documentation of collections is also critical.

Table 2: Botanic gardens and known cultivated accessions

Country cultivation	No. of botanic gardens	No. of accessions
Ethiopia	1	100
Kenya	5	710
Tanzania	2	-
Uganda	2	3,320
Total	10	4,130

Source: Herlocker, 1999.

Drawbacks to *ex-situ* conservation

Ex-situ conservation, which helpful in man's efforts to sustain and protect our environment, is rarely enough to save a species from extinction. It is to be used as a last resort, or as a supplement to *in-situ* conservation because it cannot recreate the habitat as a whole: the entire genetic variation of a species, its symbiotic counterparts, or those

elements which, over time, might help a species adapt to its changing surroundings. Instead, *ex-situ* conservation removes the species from its natural ecological contexts, preserving it under semi-isolated conditions whereby natural evolution and adaptation processes are either temporarily halted or altered by introducing the specimen to an unnatural habitat. Furthermore, *ex-situ* conservation techniques are often costly, with cryogenic storage being economically infeasible in most cases since species stored in this manner cannot provide a profit but instead slowly drain the financial resources of the government or organization determined to operate them. Seed banks are ineffective for certain plant genera with recalcitrant seeds that do not remain fertile for long periods of time. Disease and pests foreign to the species to which the species has no natural defense, may also cripple crops of protected plants in *ex-situ* plantations and in animals living in *ex-situ* breeding grounds. These factors, combined with the specific environmental needs of many species, some of which are nearly impossible to recreate by man, make *ex-situ* conservation impossible for a great number of the world's endangered flora and fauna. However, when the extinction of a species is eminent, *ex-situ* conservation becomes the only option left to humanity. It is simply better to preserve a species in part than to let it die out completely.

In-situ conservation

In-situ conservation of biodiversity is quite simply in the maintenance of species in their natural habitats. In the case of cultivated species, *in-situ* conservation is the conservation of species in the surroundings in which they developed their distinctive properties (IPGRI, 2003; Herlocker, 1999). Its aim is to enable biodiversity to maintain itself within the context of the ecosystem in which it is found. In the case of plants, it allows them to evolve and develop as part of the ecosystem of their natural habitat (FAO, 1999). On-farm conservation is one of *in-situ* conservation. Farmers have long been aware of the relationship between the stability and sustainability of their production systems and the diversity of the crops they grow. In fact, farmers created most of the crop diversity we see today, by selecting the various qualities they wanted from each year's harvest. This was often unconscious. Sometimes it was a deliberate act of saving the best seed to grow next year's crop.

Home gardens have also recently been recognized as central to *in-situ* conservation (IPGRI, 2003; FAO, 1999). They often serve as refuges for crop and crop varieties that were once more widespread in the larger agro-ecosystems. Farmers use home gardens as a space for plants with little or no world market value. This may be because they often important nutrient combinations or are of special importance to local food culture. They may also hold religious significance for the farmer. Home gardens often also serve as sites for experimentation and introduction of new cultivars. It is therefore, crucial to understand their dynamics so that they can take their place as a component of *in-situ* conservation of our rangelands. *In-situ* conservation provides a broad genetic base, maintenance of population structure, stability of population numbers and opportunities for future adaptive expansion. The various forms of *in-situ* conservation includes forest and nature reserves, national parks, game reserves, plant sanctuaries, designated genetic reserves for wild relatives and biosphere reserves (Hoyt, 1992).

The major advantages for *in-situ* conservation relate to the availability of technologies and the utilization of the breeds. This conservation approach provides incentives to local farmers to act as custodians of traditional varieties and selections nurtured in their fields and backyards (Attere *et al*., 1991). Moreover, *in-situ* conservation of live population requires no advanced technology because the farmers and pastoralists know how to manage and maintain their local strains. *In-situ* projects can ensure that financial commitment to the conservation of animal genetic resources involves helping to improve the livelihood of farming communities associated with the breeds targeted for conservation. They do not require the importation of expensive materials, skills or requirement. *In-situ* projects enable breeds to be properly characterized and evaluated in their own and related localities. This method of conservation also allows populations to adapt to changing environmental conditions and endemic diseases.

Drawbacks to *in-situ* conservation

The disadvantages of *in-situ* conservation are brought about by a lack of complete control over the many factors, which influence the survival of individuals and therefore the genetic makeup of the conserved population. *In-situ* conservation projects require land and people that are limited resources in some regions of the world. Genetic drift is an inevitable feature of all live animal conservation projects, even when steps are taken to minimize the problem. Selection and the resultant shift in the genetic frequencies within a population are a real possibility, and may even be a legitimate objective of some programs. *In-situ* conservation incurs the possible threat of disease eliminating whole or substantial parts, of a conserved population, particularly if the conserved herd is in a single or only a few linked locations. Diseases may also act as a major selection pressure within a population, and may substantially change its characteristics. Finally, live animal conservation program do not assist in the easy of transfer of animal genetic resources as compared to the movement of frozen material. Moving live animals is relatively more expensive and there are international restrictions on the movement of animals to control diseases.

In-situ versus *ex-situ* conservation

The relative advantages and disadvantages of the major systems are therefore reviewed here with a view to identifying the relative strengths and areas of mutual support (Table 3).

Major causes of genetic erosion in rangelands

Population pressure

Population increase in eastern Africa during the last three decades has been growing high. According to Fratkin (1994), most of the population increase has taken place in the higher potential agricultural areas of the region. Because of this, migration took place to high potential rangelands. Rapid population growth necessitates expansion of human settlement in areas

formally occupied by habitats of various plant and animal species. Moreover, increased population puts pressure on readily available natural resources and thus have resulted in widespread overexploitation of rangeland resources (Herlocker, 1999; GoT, 1998). Increasing population pressure is tending to push arable farming into more and more marginal areas. This in turn places further pressure on pastoralists and foragers and thus on rangeland vegetation leading to widespread degradation of rangeland resources and erosion of rangeland biodiversity. Urbanization which is a result of rapid population pressure growth continues to exert pressure on biological diversity through demand for charcoal, hard wood, food resources and exploitation of birds and animal products.

Table 3: A comparison between *in-situ* and *ex-situ* methods

Items	Ex-situ	In-situ
COST- Initial set up cost	High	Low-high
-Maintenance cost	Low	Low-high
Genetic drift -initial	High	Low
-annual	None	Moderate-high
Applied to all species	No	Yes
Safety/reliability	Good-bad	Moderate
Local access	Moderate- poor	Moderate-high
International access	Good	Not good
Population monitoring	None	Good
Environmental adaptation	None	Good
Selection for use	None	Good

Source: IPGRI, 2003.

Government policies

Government policies have often been basic causes of deterioration of rangeland biodiversity. In most cases, policy framework for biodiversity conservation remains weak in many sectors. This endangers the continued use by pastoralist of their better rangeland areas because, even if the government does not directly alienate land for farming, subsequent land disputes between farmers. The imposition of land tenure changes, settlement and irrigation schemes, state farms, national park and game and forest reserves often removes valuable dry season grazing areas for use by pastoralists. Loss of these high potential rangelands concentrates growing populations of pastoralists and livestock on smaller areas of less productive rangelands, leading to increased competition for and overexploitation of rangeland resources. The ranches have interfered with the flexibility and mobility of traditional grazing systems needed to maintain both and optimal number of pastoralists and rangeland biodiversity and productivity (Fratkin, 1994). Generally, there is tendency to have several institutions dealing with the same resource. Spooner (1994) cited in GoT (1998), examining institutional structures for the managing of biodiversity have identified several institutional weaknesses: such as lack of effective co-ordination, overlaps in the mandate and functioning of various agencies leading to inter agents conflicts, gaps in coverage of biodiversity issues, lack of legal authority among responsible agencies and inexperience which that lack of sufficient capacity in planning and implementation of the conservation programs.

Sedentarization

The effects of overpopulation and government policies on agriculture, food availability and increased poverty have all contributed to the sedentarization of pastoralists. This has lead to concentrations of people, livestock, farming and other types of land use centered on permanent water supplies (Herlocker, 1999). These sites become centers of overuse of rangeland resources and subsequently, of rangeland degradation and reduced biodiversity (Herlocker, 1999).

Breakdown of traditional institutions and resource utilization

Local control of rangelands eroded by government appointed chiefs, whose ultimate loyalty is to government party rather than tribe (Herlocker, 1999). Loss of land to other uses or because political borders or insecurity inhabit movement into traditional grazing areas reduces mobility and flexibility, which underline traditional pastoral range management and conservation system. According to Herlocker (1999), sedentarization reduces traditional mobility and flexibility. Scarcity and subsequent competition for rangelands resources have strained traditional management systems. Dependence on famine relief foods provided by governments and donor agencies during drought as has happened with the Boran and Gabra of northern Kenya, reduces reliance on local resources for survival (Oba, 1985). The growth of a market economy has contributed to the loss of viability of traditional resource use and conservation systems. In a subsistence economy, people exploit a variety of resources so that their survival over time depends on the sustained productivity of an entire habitat.

Rangelands degradation

The rapid destruction of natural habitats, now occurring at an alarming rate also threaten biological diversity. Loss of habitat and the advent of modern agriculture have reduced diversity of cultivated plants by replacing landraces, indigenous varieties, coupled with great dependence on elite genotypes places their predecessors in danger. Rangeland degradation has, in turn depressed livestock and human carrying capacities and increased poverty. Loss of biological diversity has implications beyond extinction of species. When local plant and animal populations are wiped out, the species genetic diversity that enables adaptation to environmental changes is diminished. Eventually, entire species reach the brink of extinction. And as they disappear, the intricate link between them, their biological and behavioral associations are sundered.

Indigenous knowledge in management of rangelands biodiversity

Indigenous or local knowledge can be defined as skills, practices and technologies that are an integral part of the production system in a specific culture (Herlocker, 1999). According to Tick (1993) cited in Herlocker (1999), indigenous knowledge and practices are area-specific skills and practices concerning natural resource management, human and animal health, education etc. developed by indigenous people over the centuries. Indigenous management refers to communal resource management which is the means used to produce goods and services in order to satisfy communal needs. ODI (1992) states that, indigenous resource management

involves a serious of mechanism put into practice by rural people who in many cases co-ordinate their actions with others, at the command of some local authority they regard as legitimate and that often, management is conducted according to local knowledge systems.

Importance of ownership (tenure)

Tenure refers to the nature and range of rights that individuals have to land, water and other natural resources in relation to rights exercised by other individuals, social groups and the state. Land tenure issues are fundamental to sustainable use and conservation of biological diversity. Security of land or resource tenure influences the level of desirable resource management practices (GoT, 1998). Pastoral societies do not have tenure rights and are continually being squeezed out of their pasturelands to marginal lands. They in turn, as an alternative, migrate to areas with suitable pasture, thus adversely affecting the vegetation. Therefore, the mechanism for ownership must be our initial focus. In adapting to a harsh and variable physical environment, the eastern African pastoralists have developed principles and strategies for managing. Recently, pastoralists have had to face new external pressures, such as crop expansion into high quality rangelands, nationalization of land by governments, population increase, forceful sedentarization, and indiscriminate water development. These problems have been compounded by a relentless series of drought. These external pressures have contributed to pasture shortage, land degradation and socio-economic disintegration (Dougill and Cox, 1995).

Traditional herd management

The main production objectives of pastoralists are not only increasing herd size, but also increasing milk yield, maintaining an appropriate herd structure for short and long term reproductive success, and ensuring disease resistance by selective breeding (Monod, 1975). Development objectives must therefore, take this heterogeneity into account, which reflects and at the same time enhances a diverse production base. The flexibility of the system is an insurance policy that sustains the livelihood of a family and therefore a sustainable production base. Pastoralists always try to maintain a diverse portfolio of livestock designed to meet their needs and to fit the environment. The traditional African pastoralists have accepted and adapted to environmental diversity by having a herd of mixed species. Cattle and sheep rely in large part on grass (but also some forbs and browse especially in the dry season), while camels and goats rely mainly on browse.

In the Ethiopian rangelands, herd splitting, the practice of dividing the livestock into separate herds depending on their age, sex, type and productivity, is widely practiced (Alemayehu, 1998). Pastoralists frequently separate large ruminants from small ones, as among the Rendille of Kenya (Fratkin, 1986) and the Masaai of Tanzania. Herd splitting results in increased niche specialization, in reduced competition among livestock for the same vegetation and in a dispersion of grazing pressure as each type of livestock is taken to the pasture which suits it best. Herd diversity and splitting are techniques that can be used to maintain the long term productivity of the range, to ensure sustainable production at a comparatively low cost, and in some cases to improve degraded rangelands. Herding is the art of guarding and conducting livestock. Development programs should therefore encourage herders to stay on a range, retraining them with a combination of viable traditional and appropriate modern techniques.

Traditional range management

Although the quantity and quality of water and forage are of paramount concern to pastoralists, other factors also determine movement patterns. These factors include location of salt licks, soil conditions, other environmental factors, avoiding pest and disease areas, avoiding damage to crops, proximity to markets, household labor availability, cultural gatherings, territorial boundaries, and social relations with neighbors. Al of these factors introduce a high degree of flexibility into pastoral movements, which is often interrupted by development workers and government as inconsistency and irrationality. Mobility is one of the best-adapted and effective means of obtaining what livestock need in an ever-variable environment (Baruch *et al*., 1996). In the traditional African context, movement is not chaotic but is regulated by socio-political controls and technical know-how. It requires access to large areas of rangelands, which most groups obtain by a combination of territorial rights and alliances with neighbors. Herders from the same social unit are usually free to use any part of their territory, but in practice confine themselves to the range they know best, and prefer to stay with the same group of people, especially relatives. This usually ensures a continuity and consistency in range use by the same managers.

Most pastoral groups have several types of range management techniques including pasture rotation/deferment and grazing reserves. These techniques are frequently used to save forage for critical periods. The monitoring and evaluation of changes in indicators of environmental health enable herders to adjust their forage management and conservation strategies to the long and short term availability of resources. Several parameters are use to include milk yield, grass and browse availability and the presence and abundance of specific plant and wildlife species. Evaluation of pastures and knowledge of the process of degradation can be quite detailed. These traditional environmental indicators are still in use and have become more pertinent as resource shortages have increased. Up to now, these traditional rangeland monitoring systems have not been used in the development context, perhaps because they did not fit into the classical fenced 'ranch' model. Their effectiveness, enhanced by modern husbandry techniques and the relatively low cost of hiring herders as local range monitors, are advantages that can form an integral part of more effective range development program. In some ecological zones, rotation strategies can also be used to increase rangeland capacity by deliberate overgrazing. Although these traditional techniques are gradually disappearing, many of them can be received and can form the basis of rangeland development.

Integration of traditional methods into formal *in-situ* conservation

The conservation of rangeland biodiversity requires the adoption of a coordinated and integrated approach involving the relevant government and research institutions, NGOs, the private sector and grass root communities. *In-situ* conservation needs to be integrated into the overall national environmental planning and management strategies in order to obtain maximum benefits. According to Hoyt (1992) the important prerequisites for *in-situ* conservation include formulating objectives and priorities, selection and design of conservation areas, harmonizing conservation with human needs, the integration of management strategies with the land use of the surrounding area and continuous ecological monitoring allows the comparison of objectives and achievements and shows decision makers when changes in approach are needed. The integration of indigenous institutions, environmental knowledge and traditional management practices in conservation activities is a good entry point for obtaining the participation of local communities in conservation/ development efforts and ensuring the perpetuation of important elements of local culture (Herlocker, 1999). It is necessary to the success of *in-situ* conservation efforts that the local people feel that they are involved in the effort, that their rights are being respected and therefore that they will gain form the process. For this reason, the local people need to be directly involved in planning and implementing environmental conservation interventions which are likely to affect their livelihood.

The economic valuation of biodiversity, both in terms of local users and in relation to ecosystems services and devising mechanisms to provide incentives to maintain biodiversity at the local level within a variety of socio-economic matrices are necessary. Also evaluating the cost-effectiveness of different conservation approaches including foragers, pastoralists, ranchers, arable farmers, local and national governments need to be considered. Conservation approaches must recognize that rangelands are physically and institutionally fragmented. As population increase the number and types of claim on these lands expand, crosscutting and interlocking with one another. Nevertheless, maintenance of habitats should be greater concern. Therefore, it is important to create incentives at the local level to conserve biodiversity. Landowners and users should be awarded a larger share of the total gains from conserving biodiversity. Mechanisms, which can be used for this purpose, are subsides for conserving biodiversity; payment of royalties on the use of genetic material conserved and utilization of conserved areas for tourism with income transfer.

Conclusion

From all that has been said above it should be clear that the rangelands of eastern Africa are characterized by a high biodiversity, which is economically important both locally and nationally. Rangelands are especially important, however, as the principal support for pastoralists, a large number of whom still live a basically subsistence existence. Pastoralists have, over many generation, developed communal tenure and land use practices, which, help them to successfully use the rangelands on a sustainable basis. Over the last few decades, rapidly increasing human populations, changing socio-economic conditions, unfavorable government polices and a degrading environment have caused the abandonment of many traditional practices. Such practices can and should play an important role in maintaining rangeland biodiversity, especially when blended with more modern scientific rangeland conservation and management practices. Biodiversity is to be maintained for the purpose of securing the livelihood of local communities. Hence then innovative strategies are required in order to secure livelihoods of the local communities.

Despite their economic and social importance and the biodiversity they harbor, rangelands have never garnered the scientific and media attention their conservation merits. The economic importance of rangelands in eastern Africa focus on the subsistence of pastoralists, foragers and farmers dependent on rain fed crops, which usually constitute the most vulnerable groups in the eco-zone. Setting priorities for rangeland biodiversity conservation is simultaneously to establish priorities for specific socio-economic matrices. Population pressure in many semi-arid regions is tending to drive arable farming into more and more marginal areas, especially with new irrigation techniques. this in turn places further pressure on pastoralists and foragers and thus on rangeland vegetation. An integrated of indigenous knowledge bended with modern scientific rangelands biodiversity conservation and management should be applied and practiced.

Recommendation

Rangeland ecosystem in eastern Africa are very dynamic systems. The modernization process-taking place, even in previously remote pastoral areas, is augmenting dynamic process. Managing rangelands in the region should be a responsibility of all stakeholders that include herders, researchers, development workers and policy makers need to make the best use of the information available and new ideas emerging about rangeland eco-systems.

It is also necessary to explore beyond the conventional wisdom of many of the traditional range management concepts in order to mange rangeland resources more effectively. Some Of the fresh perspectives on range ecology outlined above raise a whole new range of questions about the functioning of eastern African rangelands and traditional pastoral systems. They also suggest new, creative approaches to designing more sustainable pastoral development strategies in the future.

Since vegetation is the foundation for rangeland use, development range management strategies and plants requires information about vegetation ecology and an understanding of rangeland eco-system processes. This requires an assessment of the composition of vegetation at any given site and the degree of differentiation from an ideal climax plant community.

The predominant management concern for rangelands is the control of rangeland degradation through the regulation of livestock numbers. The scientific basis for this concern is the concept of rangeland carrying capacity; the number of animals that can safely be allowed to graze

without the range deteriorating. It is necessarily to help ensure the maintenance of range and livestock productivity and guard against environmental degradation. Locally maintained pasture should be encouraged in situations where local communities have adequate control over a rangeland area. Where this is not the case carrying capacity, estimates should be made basing on the fact that heavy livestock grazing lead to a decline in range condition, and that reducing or removing grazing pressure would restore the range to its previous conditions.

Since frequent drought, largely control rangeland dynamics in the semi-arid regions of the pastoral areas of eastern Africa, the pastoral system operates far from the equilibrium most of the time. However, the traditionally established reserves have played significant role in supporting the maintenance of the environment and biodiversity at large. Therefore, conservation and development program would benefit by incorporating and integrating traditional knowledge and practices. Hence, in turn this would benefit the local people by providing incentives for participation and local running of rangeland conservation and management measures.

Nevertheless, research on the relationship between livelihoods and rangeland biodiversity should be emphasized, especially in relation marginalized pastoral and forager communities. With an increased emphasis on vulnerable groups and poverty alleviation, rangelands should be assigned higher priority, since encouraging greater biodiversity would bring with it greater food security for populations dependent on the range.

Improved scientific understanding of biodiversity, notably its role in ecosystem functioning, is a precondition for increased concern and thus action to conserve it. The more local people are aware of the importance of biodiversity, the higher the value they will assign to it in decision making. Rangelands, rather like the oceans, depend on setting priorities on a local and regional basis. Conservation of biodiversity in rangelands should involve the co-operation of different stakeholders. Continuing inventory and monitoring of genetic, species, ecosystem and landscape diversity; development of biodiversity indicators; analysis of human impact on rangelands ecosystems and comparative stakeholder analysis is highly needed to develop priorities for regional action.

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