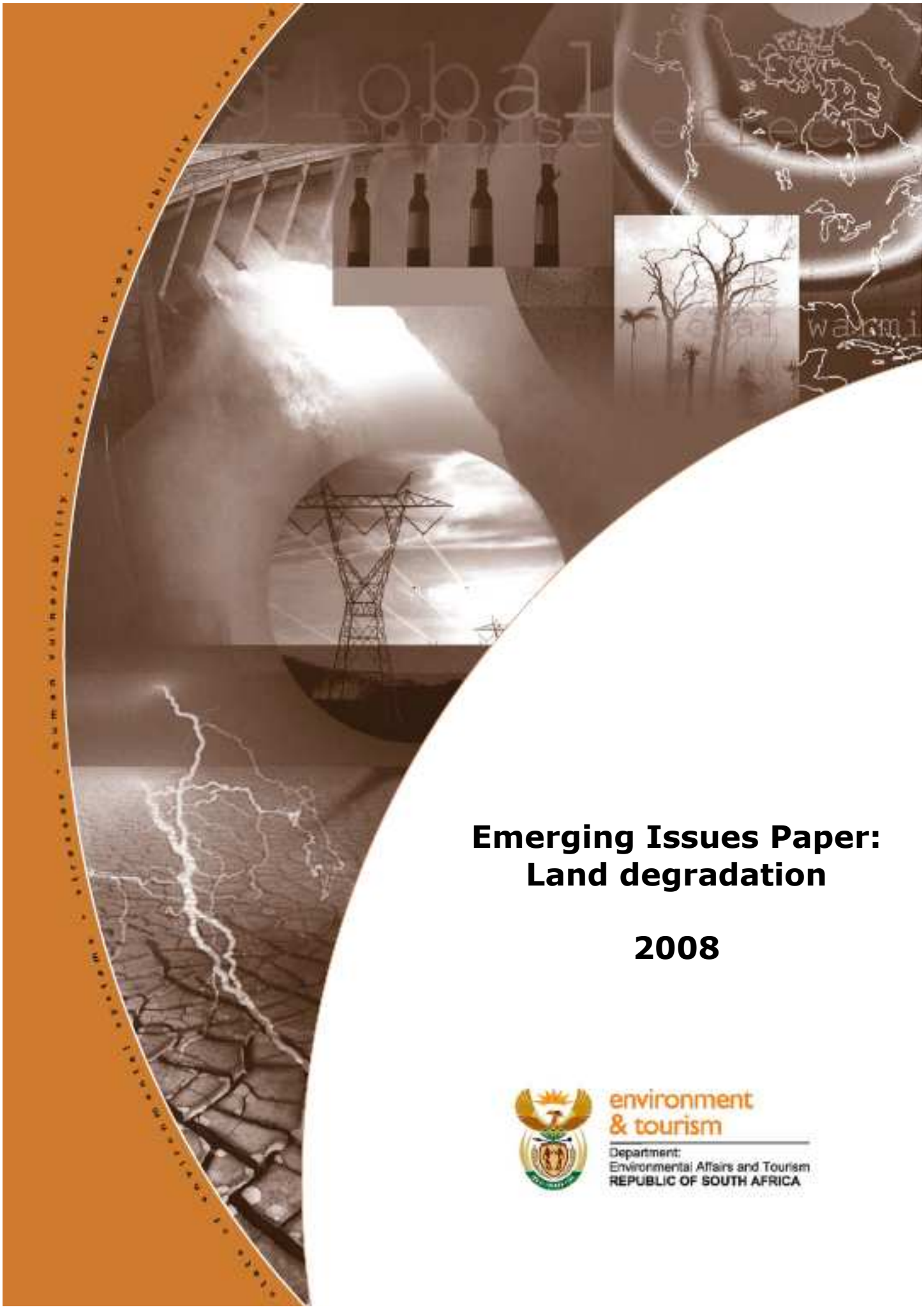

Emerging Issues Paper: Land degradation

2008

environment & tourism

Department:
Environmental Affairs and Tourism
REPUBLIC OF SOUTH AFRICA

AGRICULTURE-INDUCED LAND DEGRADATION: A CONSIDERATION OF KEY EMERGING ISSUES THAT MAY IMPACT THE STATE OF THE ENVIRONMENT

This document provides information on emerging issues that may affect the future state of the environment. The purpose of this paper is to draw attention to issues in preparation for the next state of environment reporting cycle.

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Date:

March 2008

ISBN NO: 978-0-9814178-4-4

Introduction

Land is an environmental, social and economic good and is a key resource for the realization of development opportunities (UNEP 2006). Degradation is, however, threatening the potential of land to contribute to development. According to the United Nations Convention to Combat Desertification (UNCCD), land degradation refers to the reduction or loss of biological or economic productivity of agricultural lands, woodlands and forests that result mainly from human activities, while desertification is land degradation in arid, semi-arid and dry sub-humid areas. Ninety-one percent of South Africa comprises drylands (Gibson et al. 2005), and based on the UNCCD definition, South Africa is therefore susceptible to both land degradation and desertification, and desertification is a critical issue for the country.

Although natural factors such as drought and climate change can contribute to land degradation, poor land use management and planning are key causes of land degradation. The New Partnership for Africa's Development (NEPAD) (2002) notes with concern the environmental degradation caused by agriculture in many parts of Africa. NEPAD indicates that in many places, environmental degradation and unsustainable exploitation of natural resources threaten to reduce the future productivity of agricultural land and natural resources, and that a major challenge for African countries is to ensure that agriculture does not degrade the underlying natural resource base. The issue of agriculture induced land degradation does not affect Africa or South Africa alone, but is a world wide problem (WRI 2007, Cassman et al. 2003, Robertson and Swinton 2005).

Agriculture is one of the major environment-altering human activities. At the global scale, agriculture dominates human use of land, and more area is under agricultural management than is covered by forests and woodlands (FAO 2002). Over 80% of the area of South Africa (over 100

million hectares) is used for agriculture, and 11% of the land can be used for cropping (DEAT, 2006). The remainder is used for extensive grazing as it cannot be put to more intensive uses. Land clearing for agriculture results in habitat loss and fragmentation, and this is a major threat to biodiversity. The practice of agriculture can cause land degradation through overgrazing of rangeland, over-cultivation of cropland, waterlogging, salinization and pollution by pesticides. Many agricultural practices also cause alteration of soil attributes that result in soil malfunction and, ultimately in the degradation of soil and water resources (Zalidis *et al.* 2002). While soil degradation is a major aspect of land degradation, processes such as deforestation and lowering of the water table are also part of land degradation.

Discussion

Agriculture is a complex social-ecological system in which suites of factors affect practices and choices, and these factors ultimately have implications for land degradation. Land degradation processes emanating from agricultural land use occur at different scales (local, regional and global) and are driven by physical, social, legal, institutional and policy variables. For example, global factors such as international commodity prices, national policies, local markets and social factors affect what happens to land at farm level. This section introduces some key interconnections between factors of the agricultural social-ecological system.

The conversion of natural ecosystems for other uses, and notably agriculture, is one of the most significant causes of land degradation. Change in land cover (the natural vegetative cover that characterizes a particular area) alters or destroys natural habitat, and this frequently has secondary consequences of degradation and fragmentation of remaining habitats, which result in losses of biodiversity, declines in ecosystem health and changes in the provision of ecosystem services. In South

Africa, the conversion of natural ecosystems for other uses is one of the most significant causes of biodiversity loss (DEAT 2006). Cropping and pastoral activities can thus bring about land degradation in both agro-ecosystems and natural or semi-natural systems.

Inappropriate agricultural practices can result in soil degradation in cropped areas and soil degradation is a precursor to land degradation. Soil degradation in cropped areas often manifests as soil acidification, increased salinity, organic depletion, compaction, nutrient depletion, chemical contamination, landslides and erosion. The main sources of soil degradation in croplands are biological degradation, chemical degradation and physical soil degradation.

Biological degradation is mainly linked to the decline in soil organic matter brought about by soil tillage. Tillage enhances aeration and this promotes a more rapid bacterial oxidation (decay) of soil organic matter. This can have a negative effect on soil quality, as soil organic matter plays an important role in maintaining and improving soil fertility via nutrient cycling, formation and stabilization of soil structure, reduction of soil erosion, aiding the infiltration of air and water, and promoting water retention (Xiao-Gang Li et al. 2006; Gregorich et al. 1994). Soil organic matter is also an energy source for soil microflora and microfauna, and a decline in soil organic matter results in decreases in numbers and diversity of species of soil organisms. Soil organisms play an important role in soil quality (Harris and Bezdicek 1994), are an important soil forming factor, and influence soil structure and nutrient cycling.

Chemical soil degradation associated with soil organic matter is largely related to soil acidification and fertility decline. The rapid oxidation of organic matter brought about by soil cultivation results in a net production of acid, while bases are either leached or removed in the harvest. The application of certain fertilisers also results in acidification due to the production of free hydrogen ions after oxidation in the soil (van der Merwe et al. 2000).

Soil erosion is one of the major forms of physical soil degradation. Tillage and loss of soil organic matter can accelerate soil erosion, and this can be exacerbated by soil compaction. Soil compaction is caused by the repetitive and cumulative effect of heavy machinery and can be a significant cause of soil degradation as tillage and traffic increase soil bulk density, reduce air voids and reduce porosity (Yavuzcan 2000). Compaction increases surface runoff since less rainfall percolates the soil. This increases the risk of water erosion, loss of topsoil and nutrients, and non-point source pollution of water resources (Zalidis et al. 2002). Overall, soil compaction enhances harmful physical, chemical and biological processes that in the context of inappropriate soil management, lead to soil degradation (Soane and van Ouwerkerk 1995). Soil degradation due to compaction is a concern in South Africa. According to Laker (1994) South African soils are prone to serious compaction under intensive mechanized agriculture and about 80% of the area on which maize is produced in the country is prone to compaction.

In addition, the degradation of land resources affects water resources, and vice versa. Soil degradation in croplands not only affects farming, but it also negatively affects rivers and other water bodies through siltation and pollution with agricultural chemicals. Cultivation affects the rate and proportion of rainfall infiltration, and thereby groundwater recharge and flow rates in rivers (Evans 1996). Crop cultivation can result in water salinity (DEAT 2006) and irrigation return flows or seepage may contain fertilisers and agrochemicals and can result in pollution. The state of the land has implications for the state of rivers, as the land and rivers are inseparable. River conservation is entirely dependent on sound management of the entire catchment they drain (Nel et al. 2007).

Agriculture can also lead to land degradation through rangeland or veld degradation. The manner in which rangelands are grazed, for example factors such as stock species, numbers and timing of grazing, can have a major impact on ground cover, soil loss, and maintenance and decline of plant species. Rangeland can become degraded through over-grazing, i.e. a density of livestock in excess of the carrying capacity of the land. In the

southern African region, heavy grazing by domestic livestock is considered the main cause of vegetation degradation (Ringrose et al. 1990). Heavy stocking has a deleterious influence on primary production and was observed to result in change in species composition in South Africa's semi-arid savannas (Fynn and O'Connor 2000).

Inappropriate livestock grazing can therefore lead to land degradation by upsetting the natural balance between the ratio of trees to grass in open savannas. Heavy grazing or overgrazing by livestock such as cattle and sheep removes grasses, freeing up water and soil resources for the trees to exploit. This results in bush encroachment. The problem of bush encroachment is particularly acute in the communal rangelands of South Africa, where human and livestock population densities are very high and consequently, heavy grazing (which may lead to bush encroachment) is common (Meadows and Hoffman 2002). Climatic conditions, particularly drought and variability in rainfall also play a fundamental role in this land degradation (Gibson et al. 2005), as periods of increased degradation generally coincide with periods of prolonged drought.

Consequences of land degradation

Land degradation is a cross-cutting issue and is intricately linked to food security, poverty, urbanization, climate change and biodiversity. As described above, agriculture can trigger land degradation processes, and these processes can interact synergistically with positive feedbacks having detrimental consequences. For example, inappropriate tillage practices can result in poor soil structure. Poor soil structure can result in reduced infiltration and this often leads to increased runoff and soil erosion, resulting in pollution of water bodies and negatively affecting aquatic biodiversity as illustrated in Figure 1.

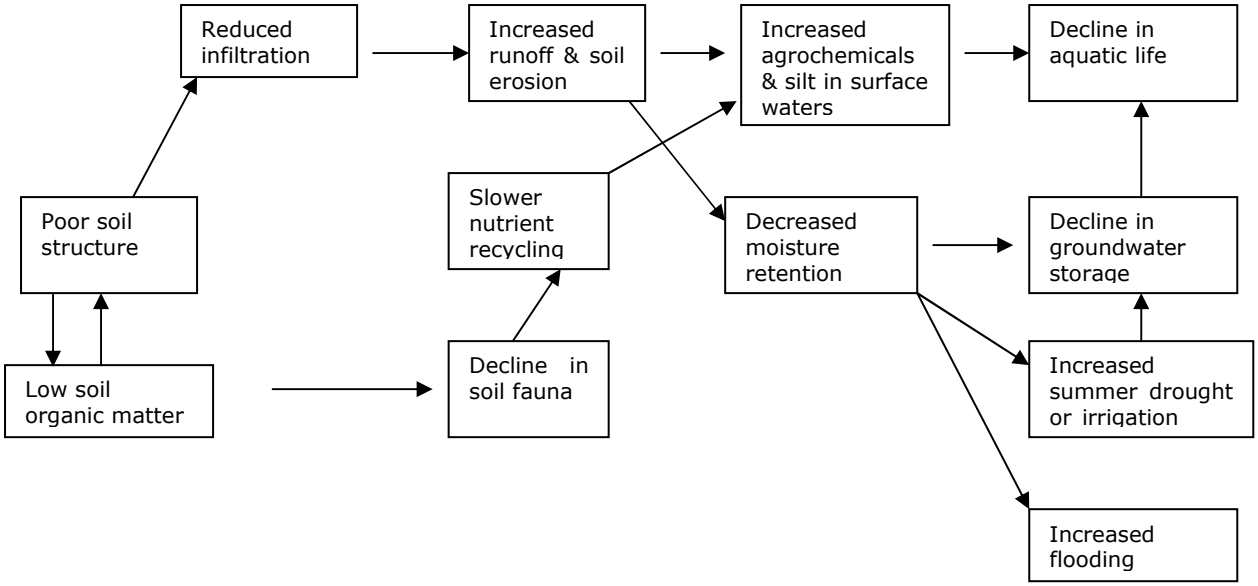

Figure 1: Soil degradation processes and their effects on the environment (Adapted from Holland 2004)

The effects of land degradation are often stated in terms of lost productivity. These effects may include reduced crop yields, reduced calorie intake, economic stress, reduced grazing intensities and loss of biodiversity. Loss of productivity threatens food security and contributes to poverty and rural to urban migration. Due to the direct relationship between the degradation of soils and degradation of water related services, the secondary costs of land degradation include decreasing ecosystem resilience, loss of ecosystem services and damage due to siltation of water bodies.

History of agriculture induced land degradation in South Africa

South Africa has grappled with land degradation caused by agriculture for many decades and negative environmental consequences of agriculture have been documented. Mather (1996) notes that the problem of agriculture and the environment in South Africa has been a concern for state officials over a long period of time. The Department of Agriculture and Land Affairs of South Africa (1996) highlighted the environmental challenges facing agriculture in the country as being soil exposure, fertility depletion, soil erosion, inefficient use of water and pollution of land and water. Over time, several studies have documented negative impacts of

agriculture on the environment including Giliomee (1992), Laker (1994), Yeld (1993), Brand et al. (1992) and Scotney (1995).

One of the reasons proposed for the environmental degradation caused by agriculture in South Africa was the rapid industrialization of South African agriculture from 1960, and this process was marked by significant increases in the use of external inputs like fertilisers (Mather 1996). The amount of inorganic fertilizer used per hectare on maize farms for example, increased from 20kg in 1966 to 100 kg in 1981 (Marcus 1989). Herbicide use also increased rapidly from the 1960s (De Klerk 1984) as did the level of mechanisation (Mather 1996). In addition to industrialization, there has also been intensification of agriculture in South Africa. The area of maize cultivation for example declined from about 4.1 million hectares to about 2.9 million hectares (reduction of 1.2 million hectares or 29%) (DEAT 2006). However, total maize production has increased, rising from 1.0 t ha^{-1} in 1987 to 3.3 t ha^{-1} in 2000. Increasing production through intensification, if not properly managed, can degrade the land.

Historical imbalances in ownership and access to land have also been responsible for agriculture-induced land degradation. Before transformation took place in South Africa, an estimated 28% of the population (13 million people) were living in the former homelands (13% of the land area). Land use practices in the homelands were characterized by high stocking rates (Meadows and Hoffmann 2002). Areas of severe degradation (both soil and vegetation degradation) and desertification correspond closely with areas with a communal land tenure system, and most of these areas formed part of the former homelands of the apartheid state of South Africa (Meadows and Hoffmann 2002). Efforts to increase agricultural output and to address conservation concerns in the former homelands were initiated through betterment schemes, but these schemes did not usually succeed.

Current situation

According to Hoffmann and Meadows (2002) most of the land in South Africa faces a degradation risk, while more than half of the county's total surface area is under threat of desertification (DEAT, 1992). Physical soil degradation is severe and is perceived to be occurring at an increasing rate in most communal croplands and grazing lands in South Africa (Hoffman and Ashwell 2001). Water erosion is the most widespread problem in South Africa, affecting 70% of the land, with rill and gully erosion being widespread (Hoffman and Ashwell 2001; Meadows and Hoffmann 2002). Soil degradation in the form of sheet and gully erosion is estimated to cover an area of 0.72 million hectares (Hoffman and Ashwell 2001). It is projected that erosion is likely to stay a problem in South Africa as an estimated 20% of the country's total area is potentially highly erodible, with geological, rainfall and topographic characteristics playing an important role (Garland et al. 1999). Low soil organic matter is also an important factor in the susceptibility of land to erosion (de Villiers et al. 2002).

Relatively, South Africa also has widespread and serious physical soil degradation in the form of crusting and soil compaction; this is higher than the global rate (Gibson et al. 2005). It is estimated that approximately 80% of the soils cultivated for maize production are prone to compaction (Laker 1994). Soil crusting, which results in increased runoff from both cultivated and uncultivated soils, hampers crop production and promotes erosion and is becoming an increasing problem in overgrazed bare patches and in areas with overhead or micro irrigation (van der Merwe et al. 2000).

Soil acidification is a major widespread chemical soil degradation issue in South Africa and is increasing, especially in low-income cropping areas, while soil fertility degradation is serious in small-scale farming areas, and in some commercial cropping areas (Van der Merwe et al. 2000; Hoffmann and Ashwell 2001). However, some forms of land degradation have been

noted to be decreasing in some commercial farming areas due to the adoption of agrobiological management of soil (Garland et al. 1999).

Veld degradation due to poor grazing management is a problem in South Africa. In 1956 it was estimated that almost 13 million hectares of veld in South Africa had been badly affected by bush encroachment, and by 1983 it was estimated that 33% of southern Africa's bush, scrub and savanna vegetation had been invaded and dominated by woody species (Department of Environmental Affairs 1999). Stocking rate is an important factor in veld degradation, and Gibson et al. (2005) indicate that total stock densities in all provinces of South Africa exceed the long-term grazing capacity of the veld. Overstocking is generally most evident in provinces with large areas of communal rangelands, i.e. the Eastern Cape, North-West, KwaZulu Natal and Mpumalanga (Gibson et a. 2005).

Given the above, the emerging consequences of climate change could have a severe effect on the resilience of the systems described in this essay. Greater attention will need to be focused on actively adapting to variations in rainfall, as this is a key driver of land production systems. Current responses to events like droughts tend not to react fast enough to prevent a sustained pressure on land during these times of stress, and also do little to reduce pressure during critical recovery times after the event has ceased. Land degradation is therefore a likely result of such practices, which creates a positive feedback in the system – i.e. a continuously decreasing quality of land resources.

In this regard, it appears wise to give higher consideration to the broader socio-economic setting and status of farmers and their communities, as well as to the development of support structures for them (particularly in cases of land restitution, where knowledge and/or coping mechanisms are typically poor leading to increased vulnerability). In addition, the evaluation and demonstration of broader ecosystem services and trade-offs associated with land use and degradation should form a central priority. Long term monitoring for and by agricultural authorities and farmers also needs to be promoted, to facilitate adaptive learning. This

should be coupled with community based resource management techniques, and instilling a sense of local ownership and management responsibility, in order to be effective.

Conclusions

Land degradation associated with agriculture has been acknowledged to be a problem in South Africa for many years. Agriculture-induced land degradation, although not a new phenomenon, should be treated as a serious environmental issue mainly because it has not been effectively addressed in the past and is continuing. While milder forms of land degradation can be reversed through appropriate land management, more serious forms of degradation such as salinity may be very difficult or impossible to reverse. If nothing is done and a 'business as usual' attitude is adopted, the negative changes set in motion by land degradation could be amplified through positive feedback loops in the social-ecological system, and the degradation could end up being irreversible. Land degradation is not only an issue of the present, it also has past and future dimensions. Land degradation can be inherited from past activities, and anything done at present could affect future generations. It is necessary therefore to learn from the past, apply current best practice and protect the future by addressing land degradation.

Land degradation has tended to be dealt with on a sectoral basis. In the agriculture sector, for instance land degradation has been treated as an agricultural problem and attempts to address it were focussed on the sector as evidenced by various pieces of legislation. These responses ignored the various inter-sectoral drivers of land degradation. A possible way forward would be to address land degradation in a holistic manner, involving all sectors which drive land degradation, both directly and indirectly. It also has to be borne in mind that agriculture is a necessary part of human existence and cannot cease. What is important is to have a vision for the future focussed not only on meeting human needs for food

and other commodities, but also on maintaining ecosystems services. Land degradation thus needs to be brought to the fore of decision making and implications of decisions on land degradation must be weighed. The effects of climate change and increasing vulnerability of agricultural social-ecological systems (especially linked to land restitution activities) require proactive and innovative intervention.

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