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CONTESTING VIEWS AND CHANGING PARADIGMS

The Land Degradation Debate in Southern Africa
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Introduction

The remedy lies, indeed, [...] in correct intellectual habits, in a predominant, ever-present disposition to see things as they are, and to judge them in the full light of an unbiased weighing of evidence applied to all possible constructions, accompanied by a withholding of judgement when the evidence is insufficient to justify conclusions" (Chamberlin 1890: 96, "The method of multiple working hypotheses", Science, Vol. 15, 1890).

The debate on environmental change in the drylands of Africa, especially in the context of land degradation, is fraught with confusion and disagreement concerning the magnitude, severity and causes of observed changes (Warren & Agnew 1988). One reason for this is the proliferation of contradictory definitions of land degradation (Verstraete 1986, Toulmin 1993). Another is the uncertainties and inaccuracies inherent in the methodological tools and analytical models (Stocking 1987, Gill 1993). Of more direct concern to the people of the drylands is the common inability to apply research results and experience of development work in an appropriate way to projects and policies (Thompson & Warburton 1985).

In reviewing recent literature on land degradation in Africa, specifically Southern Africa, the need to understand the causes behind the inherent contradictions became imperative. On the one hand, there exists a common belief that inappropriate farming methods and overgrazing are turning large parts of Africa into deserts (e.g. Bourlière 1983). For a long time this has been the ruling theory behind much scientific research as well as applied project and policy design. On the other hand, a growing number of scientists claim that dryland degradation is neither as severe nor as widespread as has hitherto been presumed (Bie1992, Biot et al. 1992). This latter belief is based on many arguments, one of the more important being that many indicators traditionally used to identify degradation should more correctly be interpreted as natural and reversible traits of an environment characterised by variation and stress (Behnke et al. 1993). This emerging new paradigm is based on a critical examination of conventional assumptions about the semi-arid environments of Africa (Warren & Khogali 1992). A picture is emerging of an environment more resilient than we have traditionally assumed, and where stability and sustainability have to be defined according to local conditions and with an appropriate time scale.

New ideas concerning the dynamics of semi-arid environments have been inspired by studies of indigenous ecological knowledge, as well as a re-evaluation of local land use systems. Many now recognise that indigenous practices are often
better suited to local conditions than imported western techniques (Fairhead 1992). Traditional methods of measuring and evaluating environmental conditions and changes are being challenged. That environmental change and degradation also involve socio-economic and political processes is becoming recognised (Blaikie 1985, Blaikie & Brookfield 1987a).

There is a need to re-examine established assumptions about the nature of environmental change. A possible outcome of such an exercise could be that many instances of so called "degradation" should, more accurately, be described as examples of environmental change. This paper does not deny that increasing pressure on natural resources is causing a decline in the productive capacity in many areas. However, it does raise the question: to what extent are statements on land degradation issues based on a thorough understanding of an ecology characterised by change, variability and heterogeneity? Or: to what extent are they based on ever-changing perceptions of nature and the relationship between man and the environment? One important outcome of this discussion paper is that the decision of whether the observed changes are negative or not should be based on an integrated analysis where local conditions and perceptions, ecological as well as socio-economic, are taken into account.

This paper attempts to cover some of the wide range of issues that have been brought into the debate on environmental change and degradation of the semi-arid lands of Southern Africa. Within this vast field of references I will concentrate on discussing recent studies on the subject. In section two, commonly used definitions of land degradation and desertification are examined. Causes of degradation are briefly reviewed, as well as statements on the severity of the situation and the status of present research. Causal links and indicators of degradation are explored in more detail in the following section. Thereafter, in section four, contradictory evidence of degradation is presented. Examples from Botswana, Zimbabwe, South Africa and Swaziland are discussed.

Section five aims at demonstrating how aspects of time and space, and the perception of these concepts in relation to environmental conditions, have influenced studies of degradation. It exemplifies how an application of different temporal and spatial scales can affect studies of environmental change and degradation. Theories of equilibrium and non-equilibrium ecosystems are introduced. The subsequent section shows how ideas about non-equilibrium ecosystems are changing traditional models, approaches, and methodologies. Such concepts as state-and-transition models and carrying capacity are discussed. Section seven reviews the present state of research and recommended future approaches of certain aspects of the degradation issue. In the final section the main points of the review are summarised and some suggestions for future research are discussed.
1. Land Degradation and Desertification Defined

Over time, numerous definitions of land degradation have been formulated. Today many of these are in use simultaneously, and this proliferation is causing much confusion, thereby undermining the credibility of the debate. A review of some of these definitions reveals that the differences have less to do with changing environmental conditions, and more with changing perceptions of the relationship between man and the environment.

Definitions

Scientists of different disciplines, development agencies, government bodies and international organisations have formulated their own definitions of land degradation and other key-terms used in the debate (Toulmin 1993). Some of these definitions have brought new and important insights to the debate, but most have simply added to the confusion about the severity and causes of land degradation. Several authors have tried to formulate agendas for future research in which general definitions and statements can be adapted to specific and separate case studies (see e.g. Verstraete 1986, Warren & Agnew 1988, Grainger 1990, Mainguet 1991, Warren & Khogali 1992, Biot et al. 1993). This work is, however, far from easy.

One major disagreement concerns the meaning and use of the term desertification. The concept of desertification was first introduced by Aubreville (1949), and since then it has acquired a number of contradictory and often ambiguous meanings, some of which have been reviewed by Verstraete (1986). Some authors include the humid tropics in the definition of desertification. Others strongly refute this, claiming that only processes in the arid, semi-arid and dry sub-humid areas should be discussed under this heading (Warren & Agnew 1988). There is also disagreement concerning which physical processes should be included. Some discuss desertification only in terms of soil erosion, while others include a whole range of detrimental processes, e.g. salinization of irrigated farmland and the accumulation of toxic wastes near towns (Sanders 1986).

At first, the general perception of desertification was that of expanding deserts, mainly in the Sahel region, and this is still the common public understanding of the term. Within the scientific community it is only since the 1970s that the emphasis of the term has shifted to mean "the degradation of otherwise non-desertic regions from within, rather than on an invasion from outside" (Verstraete 1986: 8). In 1991, in preparation for the UNCED conference in Brazil, the United Nations Environmental Programme (UNEP) adopted the following definition:

Desertification is land degradation in arid, semi-arid and dry subhumid areas resulting mainly from adverse human impact (in Helldén 1991:372).
while degradation implies a reduction of the resource potential by one or a combination of processes acting on the land, including water and wind erosion, sedimentation and siltation, long-term reduction in the level of diversity in natural vegetation, crop yields, soil salinization and sodication (Helldén 1991:372).

As compared to earlier definitions by the United Nations (UN) some important points had been changed. The statement that land degradation would result in desert-like conditions had been excluded, as had the implication that the causes of degradation were due solely to the influence of man. However, in many studies on desertification it is still implicitly assumed that development of desert or desert-like conditions is the main threat to large areas in the arid and semi-arid regions of the world (Rapp 1986, Cardy 1993).

Subsequent to the 1992 UN Conference on Environment and Development (UNCED) in Rio de Janeiro, the official definition of desertification was modified again. It now defines desertification as:

Land degradation in arid, semi-arid and dry sub-humid areas resulting from climatic variations and human activities (in Toulmin 1993).

The differences might not seem big, but are actually quite significant. The emphasis on anthropogenic causes for degradation is reduced even more, and instead climatic influences are seen as a possible important cause. As yet, no scientific consensus exists as to the possible occurrence and degree of present and future global climatic change (IPCC 1992). Evidence for more specific environmental effects in different regions is also lacking (Melillo et al. 1990), although changes in soil, vegetation and faunal life are anticipated (Parry 1990).

With a slight, but interesting, modification, this UN definition is being used by the international committee on desertification issues set up as a result of the UNCED conference. This committee is presently negotiating the final text for "an international convention to combat desertification in those countries experiencing serious drought and/or desertification, particularly in Africa (INCD)". In the final draft of the convention text desertification is defined as, "Land degradation [...] resulting from various factors, including climatic variations and human activities", (our emphasis) (INCD 1994: 4).

A 'classic-type' definition of land degradation is presented by Arntzen & Veenendaal (1986). They state that land degradation comprises "all processes which cause bush encroachment, soil erosion and ultimately result in desertification". Here desertification refers to "land degradation which is difficult and/or costly to reverse". Rangeland degradation is said to reflect "structural over-utilisation of land as well as temporary effects of drought" (ibid.142). With a different perception of man-land relationships, Warren & Agnew (1988) use changes in productivity as one of the main factors in defining land degradation. The links between soil erosion and productivity are briefly reviewed by Ponzi (1993), who stresses that present changes in productivity, e.g. declining crop yields, must be distinguished from changes in long-term production potential. Through inputs such as fertiliser and extra labour, productivity can be restored or even increased, although the real soil productivity is decreasing. In other cases,
one has to establish that environmental change really has occurred, and that a measured productivity decline is not due directly to socio-economic factors which might be of a temporary character. In order to establish this, changes at different temporal and spatial scales must be investigated (Warren & Agnew 1988). These aspects must also be taken into account when evaluating a further important criterion of degradation, i.e. if the resilience of the system has been permanently damaged or not (ibid.). This reasoning is similar to that of Nelson (1988), who states that:

Desertification is a process of sustained land (soil and vegetation) degradation in arid, semi-arid and dry sub-humid areas, caused at least partly by man. It reduces productive potential to an extent which can neither be readily reversed by removing the cause nor easily reclaimed without substantial investment (ibid. 2).

He introduces the importance of distinguishing between reversible and irreversible changes when discussing land degradation. However, he acknowledges that a simple exclusion of short-term changes, and the loose definition of irreversibility used here, present difficulties. The importance of being clear when discussing 'irreversible changes' is also emphasised by Myers (1988). He points out that even severely stressed land can revert to a less degraded state, given enough time. The definition presented in Abel and Blaikie (1989) refers mainly to rangeland degradation, but their definition has since then been given a more general meaning:

[The term land degradation is taken to mean] an effectively permanent decline in the rate at which the land yields livestock products under a given system of management. 'Effectively' means that natural processes will not rehabilitate the land within a time-scale relevant to humans, and that capital or labour invested in rehabilitation are not justified. [...] This definition of degradation excludes reversible vegetation changes even if these lead to temporary declines in secondary productivity. It includes effectively irreversible changes in both soils and vegetation (ibid. 113).

Arntzen (1990) does not agree with their definition. He claims that in reserving the term degradation for ecologically irreversible changes it becomes too narrow. Instead he advocates a broader definition which states that "man-induced decreases in productivity are considered rangeland degradation when they have a lasting impact on rangeland productivity" (ibid. 472). This introduces some additional important points, namely that declining productivity can only be judged in relation to a specified land use, and that damage to the environment must be related to the cost of rehabilitation. This is also stressed by Warren & Agnew (1988) and Biot (1991a), who emphasise the role played by economics. The latter defines land degradation as,

an environmental process which occurs when the ability of the land to produce the goods and/or services people demand from it is found to be declining. [...] Thus, what matters in the case of land degradation is not the reduction in soil depth or the increase in salinity, the reduction in organic matter or surface sealing, but its impact on the ability of the soil to generate 'well-being' through the range of goods and services this land produces. Economics is a fundamental part of any definition of and deliberation about land degradation (Biot 1991a: 2).
The awareness that the cost of declining productivity must be included in assessments of degradation is growing (Ponzi 1993). However, due to a lack of documentation and to problems of measurement, analyses often concentrate on a single issue. For example, in studies of soil erosion and soil conservation costs are often measured only in terms of crop yields and livestock prices. External effects on environment and society are left out, which creates a skewed picture of the true costs involved (Bishop 1992).

In a recent assessment of land degradation, Warren & Khogali (1992) distinguish between drought, desiccation and dryland degradation, processes which in their view require different types of intervention. Drought is defined as a period of two or more years with below average rainfall from which an ecosystem will usually recover quickly. Desiccation is the result of a longer dry period, measured in decades, and from which ecosystem recovery will be much slower. Finally, on the issue of degradation they state that:

Dryland degradation is land degradation in drylands brought about mainly by inappropriate land use under delicate environmental conditions. Land degradation is a persistent decrease in the productivity of vegetation and soils. Dryland degradation differs from land degradation in humid areas in that wind erosion and salinization are much more active in these than in humid climates, and also in that other common degradational processes, such as water erosion, occur within the special semi-arid context in which seasonal and longer-term drought produces distinctive types of surface conditions (ibid. 6).

An additional term which has come to be used in the context of global environmental change and degradation is that of 'environmental criticality'. This is defined by Kasterson et al. (quoted in Brookfield 1992: 1) as a situation that arises when "human occupation has so changed multiple components of the environment that the quantity and quality of those uses and/or the well-being of the population cannot be sustained, given feasible socio-economic and/or technological responses". According to Brookfield (ibid.), 'environmental criticality' is sometimes used to describe situations which are critical to humans, but which do not involve environmental changes. He does not agree with this broader definition, "environmental criticality should be reserved to mean criticality of the biophysical environment, and not simply that of the people who live in it. [...] this is environmental criticality only if the hazard arises from causes that are embedded within the natural environment, or arise from changes that have taken place in that environment" (ibid. 2).

It might seem irrelevant to dissect definitions the way we have done here. However, statements on land degradation and desertification are central to many scientific texts and policy reports, and it is vital to be aware of the different meanings that can be ascribed to these terms. Recommendations for future land use, including restrictions and incentives, will vary depending on how past and present environmental changes are interpreted and evaluated. The term "desertification" has been especially criticised as being nonspecific and unscientific. In spite of this, many are of the opinion that since it is so commonly used it is better to keep it, than to add to the confusion by introducing a new terminology (Verstraete 1986)
– provided that the term is carefully defined. However, it is argued here that the
term may still be misunderstood by non-specialists when used for instance in gen-
eral UN documents, and that therefore it should be avoided. Even the use of the
less dramatic term "land degradation" can result in misunderstandings. An alter-
native might be to use the phrase "environmental change" more often, thus forc-
ing each user to specify the changes and to discuss whether land degradation has
occurred, and if so according to what criteria. This could be one way of clarifying
the debate.

**Changing views: Is land degradation occurring?**

Not only do opinions diverge concerning definitions, affected regions and causes
of degradation. A similar lack of consensus exists about the extent and degree of
degradation. Many see dryland degradation as one of the largest threats to human
and it is highlighted by the United Nations as one of the major environ-
mental problems of our time (see quotations in Helldén 1991). This dramatic
scenario has recently been challenged (Helldén 1991, Mainguet 1991, Biot et al.
1992, Warren & Khogali 1992). Scientists have started to question research ap-
proaches, methodologies and analytical practices employed in studies on degrada-
tion (e.g. Warren & Agnew 1988). However, it must be stressed that the claim that
dryland degradation might not be as serious or as irreversible as has hitherto been
assumed does not imply that it does not occur, or that it is not an important issue

This emerging critical examination of traditional "truth" often results in an
inability to verify degradation processes one way or the other. Comparing results
from studies carried out in North, West and East Africa, an expert meeting on
desertification in 1990 concluded that: “These data sets do not confirm the hy-
pothesis of a secular, mainly man made, trend towards desert-like conditions.
They do support the hypothesis of resilience [of these dry and semi-dry ecosys-
tems]. However, they are inadequate to exclude the hypothesis of a secular trend
towards desert-like conditions (desertification) in other areas or in the same areas
in the future” (Helldén 1991: 383).

Perhaps the most important reason for this emerging 'new paradigm' is the
claim in a growing number of studies that the semi-arid savanna ecosystems,
which have been described as fragile ecosystems, may in fact be quite resilient
(Westoby et al. 1989, Mace 1991). The conclusion drawn from these studies is not
that irreversible change cannot occur, but that drastic changes are inherent in the
semi-arid ecosystem, and that these changes are often more dependent on rainfall
events than on human actions (Ellis & Swift 1988, Behnke & Scoones 1993).
Furthermore, to reach a higher level of reliability in statements on land degrada-
tion, recent research has shown the need for detailed and spatially small-scale
an interdisciplinary approach (Abel & Blaikie 1989, Livingstone 1991, Behnke et
al. 1993). These arguments will be examined in later sections of this review.
The state of land degradation research in Africa

The present state of research on land degradation issues in Africa seems to be judged in two different ways: some see a strong case for a general increase in research resources, while others claim that it is because of the proliferation of earlier research that the issue is now so confused. The latter group also advocates further research, but emphasises the need for coordinated efforts. No one could dispute that land degradation in Africa has attracted much attention over the years. In a review of research programmes on land degradation in Africa since the 1920s, Stocking (1992a) questions the usefulness of the huge number of surveys and studies that were conducted during colonial times. Mainguet (1991), when preparing a textbook on land degradation, found that the sheer amount of literature almost made the task impossible. On the other hand, Warren & Agnew (1988) state that “The huge problems of the dry lands, in Africa at least, are receiving pitifully little research. When the focus turns to research specifically into land degradation or desertification, the picture is even bleaker” (ibid. 23). Similarly, Helldtn (1991) concludes that, “The international knowledge about desertification, its status, causes and consequences is still limited. Very little research has been carried out” (ibid. 383). Further, Darkoh (1993) states that this is especially true on a national basis, and especially for the countries in Southern Africa.

The present review argues that there has occurred an uncritical collection of data, often based on flawed preconceptions about the dryland environments and communities. This has resulted in confusion as to the true state of affairs, as well as a mass of information of little value to both scientists and policy makers. However, in agreement with the above, it is also argued that degradation is an important issue in the semi-arid regions Africa, and one that is likely to become more problematic. Further research is definitely called for, but it must be of quite a different kind than what has so far been the norm. This will be elaborated on below.
2. Indicators and Causal Links of Degradation

This section briefly examines the applicability of different degradation indicators and discusses some of the causes commonly ascribed to land degradation.

Degradation indicators

Degradation indicators have been chosen and used in different ways. Systems of indicators are discussed by Mabutt (1986), who considers them valuable when establishing the magnitude of a problem, when identifying impacts of degradation, and in order to recommend appropriate remedies. He describes a number of systems where indicators are grouped either a) according to scale, i.e. global, regional and national/local, or b) by classes of variables, i.e. physical, biological, agricultural and social, or c) by major types of land use, e.g. irrigated land, rainfed cropping, pastoralism, etc.

There are many examples of bio-physical indicators; loss of vegetative cover, increased erosion by wind and water, soil crusting and compaction, loss of soil fertility, siltation of dams, loss of biodiversity, salinization, and the accumulation of toxic substances, are but a few of these (Sanders 1986, Lal et al. 1989, Grainger 1990, Mainguet 1991). Social and economic indicators, considered complex and indirect, have often been avoided. However, it has convincingly been argued that the effects of degradation must be seen in a broader context, constituting "a complex phenomenon embracing physical and biological aspects, including the human and social" (Mabutt 1986: 115). Social indicators of land degradation include increased poverty and vulnerability, increased inequality, declining health, increased migration and marginalisation and a higher risk of conflict over natural resources (Harrison 1987, Hjort af Ornas & Salih 1989, Christiansson et al. 1992). It is often argued that socio-economic indicators are of an indirect and vague character. However, as will be shown further on, in this respect they often do not differ very much from bio-physical indicators.

A recent approach when assessing degradation is to measure productivity, usually in the form of crop yields or livestock output. In Southern Africa, notably Botswana and Zimbabwe, the latter has been utilised for rangelands (Abel & Blaikie 1989, Scoones 1992a, 1992b, Abel 1992, Biot 1988), where livestock productivity has been compared with bio-physical degradation indicators. However, all too often traditional western standards of productivity are used when assessing land managed by African farmers and pastoralists. This leads to analytical errors since for land used by pastoralists it is of doubtful value to use a decline in the production of beef as an indication of degradation. Such a system is geared towards other produce, such as milk, blood and draught-power, and it is these that must be measured (Biøt 1991a, Behnke & Scoones 1993). A further limita-
tion of this approach must be noted, i.e. "declining crop yields might indicate the exhaustion of soil nutrients, but such a decline might equally be due to poor rainfall, pest attacks, conflicting labour demands at weeding or harvest, and so on" (Toulmin 1993: 8, see also Ponzi 1993). As stressed by Bojo & Rydgren (1992), a detailed examination of the relationship between soil erosion and productivity, including the investigation of other factors of importance to production, must be conducted in order to establish the impact of erosion. As yet, studies of this kind are far from common.

Fig 1
North East District, Botswana. Cattle owned by subsistence farmers, and grazed on communal land, have often been described as the main cause of land degradation in the region.

Causes of degradation
The most commonly listed direct causes for land degradation in Africa are overcultivation, overgrazing, poor irrigation practices and deforestation (Grainger 1990). For a long time the scientific consensus was that local peoples’ ignorance of proper land management was to blame (Blaikie & Brookfield 1987b). However, awareness and respect for indigenous knowledge about ecological systems and land use practices have grown (Gilles 1982, Richards 1985, Reij 1991, Fairhead 1992, Gadgil et al. 1993). Today, many are of the opinion that local people often are those best equipped to make ecological decisions about their environment. Instead, forces outside local control are being recognised as crucial in situations of overexploitation of natural resources (Chambers 1983). It is also recognised that the physical processes, although dramatic and clearly visible, are merely symptoms, and that an analysis of degradation involves a higher dimension of complexity (Nelson 1988).
Darkoh (1987) states that the fundamental disagreements concerning causal links are of a historical, socio-economic, political and institutional character. Describing the situation in Lesotho, Zimbabwe, Botswana and Madagascar as one characterised by severe degradation, he found that the main causes were a) land shortage, usually due to unequal distribution of land during the colonial era, and b) the modernisation of livestock, forestry and agricultural production which had led to the marginalisation of subsistence farming. Arntzen (1986), ascribing much of the land degradation in Botswana to a shortage of land, makes an important qualification when he adds that, "Land shortage is situation and time-specific; it relates to the ability to sustain certain levels and types of human activities at a certain point in time" (ibid. 133). What is a shortage of land for present land use practices might not necessarily be so in the future.

Causes are also defined at the national and international level. Myers (1992), albeit admitting that other factors contribute to the total effect, claims that population growth is the main agent behind natural resource depletion. This is disputed by others, who claim that there is no convincing evidence that a stationary human population, even an affluent one, would treat the environment any better (Stern 1993), and that the empirical and theoretical base for such statements is weak (Proctor 1990). At an international scale, Hulme (1993: 192) points out that "the trading structures and capital flows of the global economy (particularly the inequity between North and South) lie at the root of the dryland degradation problem...”.

Already in the late 1970s, Sandford (1976) distinguished between four main schools of argument concerning what is the main cause of dryland degradation:

- structural arguments, i.e. social and economic structures were to blame;
- natural events arguments, i.e. largely uncontrollable climatic events;
- human fallibility argument, i.e. the short-sightedness of pastoralists, governments, donors and others;
- population argument, i.e. both human and animal population growth.

It should be noted that by now many scientists have come to the realise that an explanation of any specific case of degradation or environmental change must include factors from most or all of these groups. In policy documents however, a single explanation is still often given undue prominence. In order to analyse the full range of different causes, various theoretical models have been suggested. For example, in the "chain of explanation" (Blaikie 1989), causes of many different categories are listed, from physical processes directly induced by specific land use practices under specific natural circumstances, to more indirect effects of political and financial interventions. Here factors affecting degradation are considered partly as a hierarchical system, where changes at one level interact with those "below" and "above". However, the model is more complex than this, in that it adds interactions across other boundaries, e.g. between the social and the biophysical world. The inclusion of a differentiated time perspective brings the model even closer to reality. A similar model, termed the "multi-level set of causes of
desertification”, has been described by Toulmin (1993).

A search for the causal links between land use and degradation, at whatever level, reveals conflicting theoretical models and fieldwork experiences. For example, in her extensive review Mainguet (1991) found that a clear distinction between causes, mechanisms, manifestations, and impacts of land degradation is often lacking. A common problem in this respect is the difficulty of distinguishing between environmental changes caused by human influences and those that are brought about by natural processes. One example is the discussion about drought. Today some claim that drought is a cause of degradation, while others state that it brings out destruction caused by other agents (Grainger 1990, Parry 1990, Mainguet 1991, Olsson 1992). It has been emphasised that drought should be seen as a natural part of the semi-arid environment, which the system, given time, can cope with (Ellis & Swift 1988).
3. Examples of Land Degradation?

In this section, local studies of environmental change and degradation in Southern Africa are presented, demonstrating some important contradictions. Most of the examples are from Botswana, with some from Zimbabwe, South Africa and Swaziland.

**Botswana**

In Botswana the debate on land degradation issues is as lively today as during the first decades of colonial rule, in the early part of the 20th century. Then and now, the discussion is mainly concerned with the management, or mismanagement, of communal lands, mainly through overgrazing. Botswana is a sparsely populated country, but has a high annual population growth rate, and a very uneven distribution of people. Rainfed subsistence farming, mixed with livestock grazing on communal lands, occupies the majority of the population (Silitshena & McLeod 1989). Since independence in 1966 the country has experienced rapid economic growth, mainly due to incomes from mining and beneficial trading agreements with the EEC for livestock products. The climate is arid to semi-arid with an average annual rainfall varying from 250 mm in the south-west to 700 mm in the north-east. The agricultural year is divided into two main seasons, with more than 90 per cent of the rain falling in the wet season between October and April (Bhalotra 1985). Rainfall is extremely variable both intra- and inter-annually. The coefficient of variability of the annual rainfall, measured at different sites throughout the country over the last 60-70 years, ranges from 35% in the north, to 49% in the south west. Monthly variations are even higher. In the Kalahari, low and erratic rainfall, in combination with nutrient-poor sandy soils, has produced a vegetation dominated by grass and bush savanna (Skarpe 1990). In the eastern and northern parts of the country the higher rainfall and richer soils support varied types of bush and tree savanna, with *Colophospermum mopane* being the dominant woody species over large areas (Arntzen & Veenendaal 1986).

Much of the documentation left by explorers, hunters and missionaries from the late 19th and early 20th century, describes eastern Botswana as a beautiful country, with a dense cover of trees and plenty of wildlife (e.g. Hepburn 1896, see also Kinlund in prep.). However, already in 1905 colonial administrators issued recommendations concerning the allocation of native settlements in order to prevent deforestation and overuse of the land (Edwards 1905). From the 1930s and onwards numerous reports depict a serious situation, especially in the north-east, where overgrazing and deforestation were said to have brought the land close to ecological disaster (Schapera 1971, Kinlund in prep.). Only a few reports gave a different picture. For example, the botanist Pole Evans was extremely positive...
after a visit to the north-east in the late 1930s, "[it is] some of the best pastoral country I have seen, [consisting of] a parkland vegetation carrying many valuable trees, and clothed with a rich carpet of luscious grasses" (Pole Evans 1948: 17). Schapera and his colleagues, who travelled through the same area a few years later (1942143) expressed mixed impressions concerning the condition of the environment (BNA S. 23818). However, reports warning of imminent ecological crisis continued to dominate among officials and scientists. In 1947 the Principal Agricultural Officer reported that, "This is a stricken area doomed to destruction unless major measures are taken at an early date to save it [...] I can see no practical means of reclamation other than by complete evacuation of the area with the least delay...” (quoted in Fortmann 1989: 200).

At present, the debate concerning the extent and severity of rangeland degradation in Botswana is extremely heated, as is the discussion concerning the ecological effects of different range management systems. Many authors state that the problem is severe, and that numerous examples of extreme overgrazing can be found. Others, however, claim that such conclusions are based on flawed data, that the perception of rangeland condition and range management is biased in favour of western models, and that most of the examples of range degradation are temporary conditions natural to a variable savanna ecosystem.

Overgrazing in Botswana, considered to have a strong negative impact on the natural vegetation, has been described as an automatic result of the introduction and rapidly increasing numbers of domesticated herbivores (van Vegten 1979a). In this study, as well as in others that discuss the ecology and environmental changes of eastern Botswana, evidence of degradation is reported (van Rensberg 1971, Field 1978, Cooke 1981, van Vegten 1979b, 1981, Mphinyane & Tacheba 1989). This evidence mainly consists of examples of bush encroachment, decrease in general grass density and in numbers of the more nutritious and palatable species, and of an increase of patches of bare soil. The underlying assumption that too high stock densities would upset the supposed ecological equilibrium may be found also in other studies of rangeland condition (Child 1971, Campbell & Child 1971, Arntzen 1984, 1989, APRU 1986, Cooke 1990, Hitchcock 1990).

A report to the EEC states that serious overgrazing is occurring due to the high increase in livestock numbers and the way in which livestock production is organised (Oyowe 1986). On the basis of a preliminary map of land degradation in Botswana, compiled from satellite imagery, Arntzen & Veenendaal (1986: 142) state that "range degradation processes are ongoing throughout the country". (Similar statement are often made in the debate about communal livestock management.) The authors add that data are scarce, partially lacking for the eastern part of the country, and that the intensity of degradation and the size of the affected area "are as yet unknown" (ibid.). In a later study, which examines evidence of rangeland degradation in relation to economic policies in Botswana, Arntzen (1990: 481) concludes that "rangeland degradation cannot be fully substantiated due to lack of time series on rangeland productivity and a limited understanding of the nature and extent of productivity changes; further in-depth
research and rangeland monitoring are much needed”. However, in spite of this admitted risk of errors, he claims that, based on the data available today, there are two good reasons to believe that rangeland degradation is occurring. These are the rapidly increasing livestock numbers, and the results from numerous interviews with local people who claim that lack of grass has become a major constraint to livestock development.

Another study based on satellite imagery, also concludes that large parts of the country are degraded. Ringrose & Matheson (1986) state that overgrazing and fuelwood collection have resulted in desertification, here defined as a reduction of biological productivity, both in the western and eastern parts of Botswana. Reported environmental effects include reduction of natural vegetation, increased soil erosion and a reduction in the moisture retention capacity of the soil. They claim to have found a rapid decrease in rangeland capacity, and attribute it mainly to low management standards in communal and commercial rangelands. However, the study is mainly bio-physical in character and covers a short time period. It should be noted that their land classification system includes the assumption that areas of bare soil are “largely indicative of increased soil erosion, hence desertification” (ibid. 23).

Government policies on rangeland management in Botswana are based on two main assumptions. First, rangeland degradation is one of the most serious threats to the natural resource base of the country (Government of Botswana 1975, 1990, 1991). Second, the concept of the “tragedy of the commons” is perceived as true, i.e. blaming the identified occurrences of overgrazing on communal land use practices (Abel 1992). Although the Government, individual range ecologists and many development projects vary in their estimates of degradation, most share the idea that the solution to the present situation is to be found in western-type rangeland management systems, where privatisation through ownership of water and grazing resources and extensive fencing schemes would replace traditional systems. This approach has been severely criticised by others:

- on political grounds, claiming that such reforms have caused increased poverty and inequality (Opschoor 1980, Molutsi 1986);
- on the evidence that similar policies in the past have not been acceptable to the majority of farmers, and that where they have been implemented they have failed both to increase productivity and to alleviate the pressure on natural resources (Sandford 1980, Adams 1990, Hitchcock 1990);
- on the basis of emerging ideas which state that rangeland degradation is not as severe or irreversible as has been assumed, and that opportunistic management strategies along traditional lines are more suitable in these variable environments (Abel & Blaikie 1989, White 1993).

Over the last few years several case studies have strongly opposed the view that the rangelands of Botswana are severely overgrazed and degraded. Most of these studies have concentrated on communal land, or on comparisons between these
and private ranches. For example, Fortmann (1989), in comparing historical and recent information on range condition and livestock output, concludes that in spite of environmental doomsday predictions, cattle numbers have continued to increase. Numbers fell dramatically in times of drought, but afterwards the range recovered and was able to support even more livestock than before the drought. If the range was as severely degraded as has been stated, this should not be possible.

As has been argued by Abel and Blaikie (1989), degradation should not be measured by using indicators such as short term vegetation changes. Instead changes in the environment must be judged according to their degree of irreversibility over a longer time period. In addition, degradation is primarily important only in relation to the particular use of an area, including potential alternative uses. The assessment of detrimental environmental changes must be based on estimates of secondary productivity of interest to the people using the land. Studies comparing the productivity of communal grazing lands with cattle ranches have concluded, contrary to earlier assumptions, that the productivity of the former often is higher (de Ridder & Wagenaar 1984). A case study of soil erosion on communal grazing land concluded that present land use would not result in serious erosion within the next several hundred years (Biot 1988, 1991b). This suggests that the threat of soil erosion to the productivity of the range is not as serious a problem as has traditionally been assumed (Biot et al. 1992).

Studies of environmental changes around boreholes in the Kalahari have shown that traditional degradation indicators like changes in soil characteristics, bush encroachment and an increase of annual grasses do not vary simply according to grazing intensity, but also depend on other factors, e.g. topography and variations in rainfall (Perkins 1991, van Rooyen et al. 1991). In addition, Perkins and Thomas (1993) showed that an increase of a traditional degradation indicator is not necessarily detrimental. Bush encroachment, for example, provides additional forage for cattle and protects the grass layer under the canopy, thereby preserving a grass community in times of severe grazing, and reduces wind erosion.

Zimbabwe

In Zimbabwe the official view of the condition of the country's rangelands is very similar to that described from Botswana, i.e. severe overgrazing of the communal rangeland caused by overstocking and mismanagement (Abel & Blaikie 1988). As in Botswana, this view has lately been challenged (Abel & Blaikie 1989, Biot et al. 1992, Scoones 1992a, Behnke et al. 1993).

Observations by colonial officers, as well as recent scientific studies, reported high levels of soil erosion from cultivated and grazing land. These processes were considered to be especially severe on communal land, which resulted in a number of official intervention packages, many of which have failed (Scoones 1989a, Cousins 1992). If the reports of loss of vegetation cover and increased soil erosion were accurate, then this decline in the natural resource base should result in a
corresponding decline in secondary productivity. Examining this relationship, Biot et al. (1992) found that, not only is much of the evidence of land degradation unsatisfactory, but also, contrary to expectations, crop production on communal land has increased. Scoones (1992a) demonstrates a similar increase in livestock productivity in the area he studied.

Campbell et al. (1990), examining degradation as a function of cattle stocking intensities, conclude that the issue of whether communal grazing practices cause degradation or not, cannot be satisfactorily answered on the basis of available data. They claim that there is "sufficient evidence to indicate that cattle are linked to major environmental changes in Zimbabwe", but add that their review lacks the spatial analysis needed for any detailed conclusion (ibid. 8). Scoones (1989b, 1992c) has included this aspect in his examination of grazing systems. He finds that most scientists and policy makers disregard the heterogeneity of the environment, and that this is one of the main reasons for the conflicting perceptions of environmental change. Depending on the spatial scale of a study, the results will differ concerning degree of soil erosion, nutrient depletion and reduced vegetative cover, and the effect of these changes on secondary productivity. He found that in most years local cattle owners are able to avoid irreversible damage, measured in terms of productivity, on animals and land, by utilising strategies of herd mobility and local ecological knowledge. In drought years migration between different savanna types is employed on a regional scale, in order to find grazing and browse. On a local scale, cattle will utilise different habitat types within an area, which vary in terms of grazing and browse throughout the year. Certain environmental key resources, such as riverine strips, vleis (valley bottomlands) and drainage lines, are vital in providing fodder during the late dry season and early in the rainy period (Scoones 1993).

**Swaziland, Lesotho and South Africa**

Evidence from other countries in Southern Africa also tells a contradictory story. Proctor (1990) studied signs of past and present land degradation, and estimated future trends, in a fairly small area in a highly populated part of Swaziland. He concluded that although degradation certainly existed, it was not of the magnitude described in Government reports, or that predicted by UN evaluations, studies based on generalisations on a national and regional scale. He states that: "Certainly, 'overshoot' (in the sense of growth beyond sustainable limits) has occurred at some time in the distant past; yet total rangeland collapse is not evident, and range grass is sufficient to maintain (barely) the cattle in the study area. The resultant trend is one of long-term 'low equilibrium', induced by overstocking in the more distant past, and maintained by overstocking in the present. This 'overshoot-low equilibrium' dynamic may also be applied to cropland fertility degradation" (ibid. 153).

In Lesotho, efforts to support and increase agricultural production have resulted in a number of soil conservation projects, as well as research on soil erosion
and land degradation (Ejdemark 1983). Evidence of soil erosion has not been hard to find (see e.g. Chakela et al. 1986), but this is not necessarily the major obstacle to development. Institutional problems (Dahlberg 1988), and issues of gender and household composition (Dahlberg 1987), can be more serious. It has been argued that productivity should be used as an important and integral part of any definition of land degradation (see section two of this review). A study by Bojö & Rydgren (1992) demonstrates that this aspect has largely been overlooked in the case of Lesotho, at least concerning the impact of soil erosion on crop yields. Their findings reveal that, both on a national and district level, there is "...no significant negative influence of erosion on the time trend of crop yields" (ibid. ii). This does not imply that erosion does not have an impact on crop production, but it does demonstrate that "...other factors are much more important in determining crop output" (loc.cit.).

Compared to other countries in the region, the Republic of South Africa has had more resources for in-depth ecological studies. The savannas of South Africa have been described in detail (Acocks 1988) and rangeland ecology and management has for a long time been an important field of study. This research has concentrated on western-style ranches with cattle (Barnes 1979, Bransby & Tainton 1986), sheep (Fuls 1992a) or game (Walker 1979), and less on indigenous mixed agricultural and pastoral systems (Boonzaier et al. 1990). Experimental studies at the plot-scale are numerous, e.g. condition assessments of rangelands using degradation gradients, and the ecological grouping of species according to perceived grazing value (van Rensburg & Bosch 1990, Bosch & Kellner 1991). Bio-physical
properties such as bare ground, basal cover and species composition are used to judge degree of degradation. Many of these studies are conducted over a fairly short time span (Fuls & Bosch 1991, Fuls 1992b and c). In spite of the limitation in space and time, far-reaching conclusions are sometimes drawn from these studies, e.g. "Widespread patch-selective grazing and subsequent patch overgrazing are regarded as the main cause for the continued retrogression of semi-arid and arid rangelands worldwide" (Fuls 1992c:193).

This conclusion is not unique. Studies that apply a short time perspective often conclude that the present environment is in a process of severe degradation, or already severely degraded, due to human action (Danckwerts & Aucamp 1986). Other studies, with a much longer time perspective, have instead found that environmental characteristics observed today are not necessarily the result of specific management practices, but rather of geological, geomorphological and climatic parameters acting on the landscape (McKenzie 1986). Returning to the present, many studies have concluded that traditional land use, like pastoralism and subsistence farming, are more harmful to the environment than modern ranch systems (Beinart 1984). However, a growing number of studies, applying a more integrated approach, have reached quite opposite conclusions (Boonzaier et al. 1990). Research set up to test theories of non-equilibrium ecosystems has also found that local management systems adapted to the event-driven nature of the semi-arid rangelands are less harmful than the existing western-type ranch systems (Walker et al. 1986, Mentis et al. 1989). Conservation issues are closely related to the discussion of environmental change and degradation, and in South Africa, with numerous nature reserves and game parks, it is a subject that has received much attention. A few recent studies have investigated the views of local land users concerning environmental condition and management in the context of conservation. It is clearly shown how opinions vary on what is considered degradation or natural variation, both within local communities (Hackel 1990), and between local people and scientists (Mentis 1985, Garland & Pile in prep.).
4. Environmental Change—in Time and Space

In studies of environmental change and degradation, knowledge of historic and prehistoric landscapes is important for three main reasons. First, it makes it possible to establish a series of "original" landscapes at time periods when different major influencing conditions are known to have existed (Schneider & Londer 1984). These descriptions of the environment can be compared with present conditions, which makes it possible to follow changes over time. Second, to the extent that different influencing factors can be identified and isolated, an improved interpretation of the causes for specific environmental changes can be made (O’Hara et al. 1993). Finally, some factors, like drought and land use, may be cyclic. Knowledge of the varying environmental impact of these cycles would further the understanding of fluctuations and trends, and facilitate a differentiation between temporary and permanent changes (Whitmore et al. 1990).

The paleolandscape

There exist contesting theories concerning how the semi-arid and sub-humid savannas originated, concentrating on whether they were anthropogenically formed or not (Deshmukh 1986, Skarpe 1991). Likewise, opinions diverge on the issue of which factors determine the measured and observed changes that have occurred in these environments. Fire, herbivory, and rainfall and other climatic characteristics have probably been the main agents of change, but scientists argue about their respective influence under different circumstances (see e.g. Huntley 1982, Walker 1985, Skarpe 1992). Studies of past climatic and environmental conditions constitute one link in the chain of knowledge that is needed to address issues of environmental change and degradation.

The study of paleoenvironments and paleoclimates has progressed rapidly over the last three decades, but for the tropical regions confusion and conflicting theories are still common. One reason for this is the historical practice of extrapolating evidence from one region in Africa to others. For example, climatic data from the Sahara and East Africa have been used to explain climatic change in Southern Africa (Thomas & Shaw 1991). This is now contested on the basis of recent findings in South Africa and Botswana (Holmgren 1992). In addition, it must be remembered that the large number of different disciplines, approaches and methodologies involved in paleoenvironmental research, makes reliable comparisons between studies problematic.

Investigating the origin of savanna ecosystems Cerling (1992), working mainly in East Africa, compared the carbon isotopic composition of paleosol carbonates at different fossil sites. These data indicate the proportion of plants with different photosynthetic pathways present at different times. Since these proportions vary
from open savanna to woodland and forest, the development of past ecosystems can be studied. From these and other paleodata, Cerling concludes that the savanna grassland ecosystem is a fairly recent development, more recent than has often been supposed. In investigations of this and related questions, analyses of pollen and faunal remains are also conducted. More interested in the influence of man, Feely (1980) studied a number of Early and Late Iron Age Sites in Natal, South Africa. His findings revealed that even before people started to cultivate the land, their impact on vegetation, wildlife, soils and drainage was quite profound. For example, trees were cut for different uses, like iron smelting, domestic heating and temporary shelters. In this way land, formerly covered by a dense tree-layer, was changed into a more open tree-grass savanna. This decrease in vegetation cover caused increased run-off and sedimentation in lower-lying areas, which in turn changed the soil-water relations. It is probable that land was occupied, abandoned and re-occupied again in a cyclic way, and that comparatively small areas can be described as unaffected by man. However, McKenzie (1986), working in Transkei, South Africa, found that geology, geomorphology and climate were the main determinants of the environment he studied, and that changes imposed by human land use had only been of a temporary character.

Another way of recapturing past environmental changes is through the study of paleoclimate. The methods available for these studies have become more accurate, and, for Southern Africa, numerous datings of past climate changes have been published. In spite of this, it is difficult to draw a coherent picture for the region. Data indicate that climate shifts affecting the whole region have occurred, but also that smaller scale variations are considerable. For example, as mentioned above, local data from Botswana contest previous studies claiming that the climate of southern Africa mirrors conditions in northern Africa (Holmgren 1992). In Southern Africa, most studies on paleoclimate have used findings from caves, pans, paleolakes and sand dunes (Thomas & Shaw 1991, Holmgren 1992). Studies of oxygen isotopes in paleosol carbonates can also give indications of past climate (Cerling 1992), as can research on fossil-fulgurites, i.e. natural glass formed when lightning strikes the ground. The latter has given indications of environmental conditions and shifting rainfall patterns during the Holocene, i.e. the last 10,000 years (Sponholz et al. 1993).

Evidence of prehistoric erosion processes and rates are very difficult to establish. In a study of quaternary erosion and sedimentation in Southern Africa, Dardis (1989: 1) emphasised that "little is known of when soil erosion commenced, or whether changes in the nature and pattern of erosion have occurred over time". However, in his study he concludes that forms resulting from processes of accelerated erosion, like subsurface piping and cavitation, tunnel erosion and gully development, are of recent age, i.e. formed in the past 2000 years. He suggests that the present phase of degradation started at this time, with a rapid increase over the last 250 years. Knowledge of past soil and environmental conditions is essential to the accurate assessment of land degradation in modern time. An interdisciplinary study of a severely eroded region in Tanzania adds such a
long-time perspective, in order to be in a better position for evaluating the severity of present soil erosion and the degree and sustainability of land recovery (Payton et al. 1992).

The historic landscape

Changes over historic time ought to be easier to investigate than those referring to prehistoric conditions, but such studies are far from common. When they are made, it may well be found that the official view concerning the state of the environment and the causes for perceived changes is not necessarily the correct one. For example, the widespread gullies of Lesotho were seen, by scientists and policy makers alike, as evidence of an ongoing degradation process caused by traditional agropastoral land use practices (Nordstrom 1988). On the basis of historical documentation and interviews, Showers & Malahleha (1992) conclude that the Lesotho landscape of the 1930s and 40s had not been as degraded as claimed by outsiders, and that much of the more recent soil degradation was caused by conservation works, rather than by inappropriate agricultural practices. The latter statement is also made in Chakela & Cantor's (1987) review of the history of soil conservation in Lesotho. A re-evaluation of this kind does not imply that the problem, in this case soil erosion, is of little consequence. It is clear that gully erosion, as well as other forms of land degradation, is depleting the natural resource base in Lesotho (Rydgren 1993). However, if the causal links can be more accurately established, it is more likely that we can find sustainable remedies.

Another study making use of historical documents in an analysis of environmental changes was carried out in Botswana by Fortmann (1989). She compiled and compared reports written by colonial administrators, travellers and local chiefs during the late 19th century and the first half of the 20th century. The picture of environmental condition described in these documents is mainly a very negative one. Livestock numbers were seen as too high already during the first
decade of this century, and "total devastation" would be the consequence unless destocking was enforced "immediately". Fortmann compares these perceptions and predictions with the present situation, where livestock numbers have more than doubled but where the environment is still able to support the type of mixed farming system characteristic for the region. Again, the accepted scientific truth, that mismanagement of the land had kept the rangelands in a state of extreme degradation for over half a century, may be contested. In Swaziland, Proctor (1990) used aerial photographs from the 1940s in order to compare past and present environmental conditions. He concluded that official estimates of land degradation, as well as predictions for the future, were misleading in several ways. Most important, owing to lack of historic perspective, the nature of degradation, and the causes behind it, had not been appropriately analysed.

In studies of the transition from the historic landscape to the present it is valuable to have some knowledge of conditions even prior to this. For example, the low numbers of hunters and herders found by the early European settlers on the savannas of South Africa were thought to have had a very small influence on the landscape. Game reserves were therefore demarcated on what was presumed to be "pristine" land. Vegetation changes, e.g. bush-encroachment, occurring during the present century, have been ascribed to overgrazing by wild herbivores. However, according to Feely (1980), the cause is quite different. New evidence shows that these areas have been occupied for nearly 2000 years by people more advanced than Stone Age groups, which implies that present bush-encroachment is more likely to be caused by the fact that human use of the land has come to an end.

**Varying spatial scales**

Over the last decades soil erosion and the effect of reclamation and conservation practices have been measured in detail all over Africa. The spatial scale is often that of the plot, the field or, at the most, a catchment area (Young 1976, Hudson 1981, Morgan 1986). From Southern Africa descriptions of plot and field measurement techniques in rangeland assessments are numerous, as are the studies based on these techniques (Field 1978, Hendzel 1981, O'Connor 1985, Fuls 1992a). However, as stated by Stocking (1987), "Rates of erosion measured at the field scale will, when extended to the scale of the catchment, grossly overestimate the total amount of sediment leaving the catchment" (ibid. 53). Data are also compared with, or added to, data measured with different techniques, which poses analytical problems (Stocking 1987). The study from Swaziland described above (Proctor 1990), gives good examples of how estimates of land degradation based on extrapolated figures turned out to be misleading, and to some extent false, when compared to estimates based on more small scale and detailed studies. Erosion can remove large amounts of soil from a small area, e.g. through the
dramatic event of land slides and gully formation (Temple & Rapp 1972). This can severely affect individual farmers, but might not make any difference in the total sediment load from the catchment. Soil not only erodes and disappears, it is transported and deposited somewhere (Hudson 1992). Thus, what is a negative change in one area might be positive in another, and vice-versa. Eroded soil deposited downhill or downstream might benefit another farmer, or it might cause siltation of a dam. At what scale measurements are conducted, and with what overview of related factors, has a large influence on the resulting conclusions. All too often scientists and policy makers seem unaware of this, making predictions and recommendations that may be completely false. For example, accepted estimates of soil erosion and other indicators of land degradation on the rangelands of Botswana have recently been shown to be greatly flawed (Biot 1988). In his analysis, Biot ascribes this to extrapolation errors and disregard of the heterogeneity of the landscape.

As stressed in several studies from Botswana the heterogeneity that characterises much of the semi-arid environment increases the importance of studying the effects of land use at different spatial scales (Biot 1988, Perkins 1991, Abel 1992). For example, measurements of the condition of rangeland, made by studying biomass, vegetation cover or certain key species, can give a misleading picture unless all areas utilised by livestock are taken into account. Scoones (1992c), studied land use and environmental change in the communal areas of Zimbabwe. He showed that spatially small, but commonly occurring, patches of wetlands in semi-arid regions are a key resource in African pastoral and agricultural production. Local people utilise these pockets of higher production on a regular basis, or as a reserve in times of drought, and thus overexploitation of surrounding land has been avoided. If these strategies, and the bio-physical characteristics of the different micro-environments, are not taken into account, then environmental evaluations of catchments and regions are likely to end up with errors and misjudgements.

Scale, level and hierarchy

This paper has argued the importance of choosing an appropriate temporal and spatial scale in studies of environmental change and degradation. However, several other factors also have a significant influence on the interpretation of these processes. The observed changes can be viewed as isolated, bio-physical processes, to which a geographical perspective of time and space is added. They can also, and often should, be studied as part of a larger scenario, one which involves the development and change of the society as a whole. This includes socio-economic parameters and policy-issues of a political character. Furthermore, research can be designed to look at these issues at one level only, or at a hierarchy of different levels (Blaikie 1989, Toulmin 1993).

In this context the term level is used to designate a particular place or part within a range; from the short to the long time span, from geographically small-
scale to that of nations and continents, and from the individual to that of mankind. The appropriate choice depends on the objectives and circumstances of each research project. Causes and effects are interlinked in a hierarchy of spatial, temporal and societal levels. Therefore, a realistic interpretation of changes often demands that many levels be included in one particular study. For example, research in Lesotho has clearly demonstrated the importance of a multilevel approach when studying the conservation potential and sensitivity of the environment to processes of change (Stromquist 1990). This study dealt with soil erosion surveys conducted at the regional, local and field level. Apart from the information gained from studying each separate level, the author concludes that, "The combination of the three observation levels has furthermore increased the knowledge of the process response to human impact and natural processes to a far larger extent than had been possible by only using a single level approach” (ibid. 10).

As was mentioned in section two, national and international politics and financial agreements may have a strong impact on the local environment, while changes in environment and land use in a region or nation cannot be fully explained without an understanding of the forces at work at the local level. However, studies trying to include all these aspects face many problems (Christiansson et al. 1993). These include how to avoid producing extremely complex and cumbersome reports, and how to organise and finance such major undertakings. As some of the examples in this review have shown, it is seldom possible to include all aspects that might be of relevance. The scientific approach must therefore be to be aware of this, and, when possible, indicate the likely influence of parameters that are left out. An ambition for the future would be for researchers to be more specific about what their conclusions are based on, and to try to indicate how one set of results can be linked to other studies, be they related geographically or thematically.

One way to delimit a study of change is to concentrate on a spatially small area. For example, a research project on environment and change presently being conducted in North East Botswana has a detailed coverage of only two villages. The approach is interdisciplinary with one part more environmental and the other more community oriented (Dahlberg 1993b, Kinlund 1991). Change is studied over historical time, and the ambition is to investigate local, and to some extent district and national factors, of significance for a useful interpretation. Another study, covering a larger area and involving a higher number of scientists, has been conducted in the Machakos District of Kenya (see e.g. Rostom & Mortimore 1991, Mortimore 1991, Tiffen 1992). This study looks at environmental change and dryland management over a 60 year period and combines the social and the physical at many different levels of society. With its larger resources, this project has been able to cover a large number of aspects at great detail. The aim is to combine the separate reports into a holistic interpretation, of interest both for its scientific results and for its methodological approach.

All do not agree that this broad view of change is the best approach. For exam-
ple. Abel (1992) is of the opinion that the debate on degradation must be structured according to sector interests, e.g. livestock, wildlife conservation, water supply and others. Within these sectors the interests of the different groups would be analysed separately. "Confusion over objectives and definitions is reduced. Conflicts among the groups are best resolved after the sectoral issues have been clarified" (ibid. 1.17). For a particular problem, area or level of analysis, this may be appropriate. However, in most of the semi-arid regions the inherent heterogeneity, i.e. the spatial and temporal variation of environmental and social characteristics, is such that a good picture of the past, the present and a possible future scenario can be reached only when all aspects are accounted for (Blaikie & Brookfield 1987b, Conway 1987).

Equilibrium versus disequilibrium

Recent research, particularly studies dealing with rangeland change and degradation in East and Southern semi-arid Africa, has taken a strong interest in aspects of time and space. The emerging ideas discuss environments and production systems as being differentiated by such factors as stability, resilience, sustainability and reversibility. These ideas are briefly presented below, followed by an exploration of their effect on theoretical models and methodological approaches.

The question whether savanna ecosystems of Southern Africa can be described as stable systems, or as systems in a state of disequilibrium, is one of the more controversial issues in the present debate on overgrazing and rangeland degradation (Behnke & Scoones 1993). Based on Clements’ (1916) theories of plant ecology, range ecologists in the USA developed an approach to range management which became accepted as universally valid (Westoby et al. 1989). For example, in Zimbabwe, Botswana and South Africa these theories have governed most rangeland management and monitoring projects up to today (Abel 1992). This approach, described in detail by Stoddart & Smith (1955) and Ellison (1960), is strongly based on ideas of succession and a climax state. As explained by Westoby et al. (1989: 266), “The model supposes a given rangeland has a single persistent state (the climax) in the absence of grazing. Succession towards this climax is a steady process. Grazing pressure produces changes which are also progressive and are in the opposite direction to the successional tendency. Therefore the grazing pressure can be made equal and opposite to the successional tendency, producing an equilibrium in the vegetation at a set stocking rate.” Succession, was seen as “a linear process through a set of seres, each characterised by a particular suite of species” (Abel 1992: 1.8). Each sere, or successional stage, was thought to be characterised by a situation of equilibrium between plants and animals. Through different management practices the system could be shifted from one stage of equilibrium to another, striving for the situation where certain factors, e.g. the tree/grass ratio, were more favourable to livestock production.
However, the theory of succession, combined with the traditional perception of drylands as stable ecosystems, is being seriously questioned (Westoby et al. 1989, Friedel 1991, Skarpe 1991, 1992). A number of studies on range ecology and range management from semi-arid Africa are advocating a "new paradigm" (Behnke et al. 1993). Perkins (1991) has studied the drier central rangelands of Botswana, while Biot (1988), Abel (1992) and White (1993) investigated different aspects of the semi-arid eastern parts of the country. In Zimbabwe Scoones (1992a, 1992c) and Cousins (1992), among others, have looked at ecological variation on communal rangelands. Also in South Africa, where the western approach to range management has been especially dominant, these new ideas are slowly being explored (see e.g. Walker et al. 1986, Mentis et al. 1989). All these studies have used an approach that is critical of the established view concerning the causes and effects of environmental change and degradation of rangelands.

The theories now gaining ground are based on the idea that rangelands of arid and semi-arid Africa never reach an equilibrium. Instead they represent ecosystems that can be described as non-equilibrium and persistent (Warren & Khogali 1992). These theories are not new (see e.g. Holling 1973), but interest and support for them is growing quickly. For example, Belsky (1989) states that the savanna ecosystem of East Africa is not stable over time, and that changes that occur are not necessarily irreversible. In her research she found that even when climatic and/ or soil conditions are not extreme, savannas support vegetation communities that change over time from grassland to woodland and back again. Thus, for East African conditions at least, Belsky (1990: 483) claims that "relatively natural biotic systems are characterised by non-equilibrium plant communities in which the vegetation cycles between open savanna and woodland (or thorn-scrubland)". On the basis of data from Botswana and Zimbabwe, Abel (1992) shows that in many cases stable equilibrium between rangeland plants and animals is unlikely to be established because the driving variable – rainfall – fluctuates too widely. This review argues that recent research in Southern Africa has provided empirical evidence and a theoretical framework that indicate that traditional assumptions about range ecology, especially in arid and semi-arid regions, are often flawed, and in some cases false. A re-examination of explanations, management recommendations and predictions is most definitely called for.
5. Changing Theoretical Models and Methodologies

Succession model versus state-and-transition model

The study of rangeland ecology and degradation is closely linked to that of management. However, until now the applied side has lagged behind the theoretical development described above (Friedel 1991). To be useful for management purposes ecological theory has to be formulated in the form of models which can be adopted to local circumstances.

Westoby et al. (1989), suggest a system of concepts and generalisations for range management called the "state-and-transition" model, where rangeland dynamics are described by a set of discrete "states" of vegetation and a set of "transitions" between states. A state is recognised by specified characteristics, e.g. species composition of grasses or the tree/grass ratio. However, a state is not a completely fixed feature, but can vary in space and time. Transitions between states are triggered by natural events or by management practices. The latter includes changes in livestock numbers or access to water. Often several interacting factors will be responsible for change. The aim is to discern between circumstances that represent hazards, and those which represent opportunities. Thus, range managers should not strive for a perceived permanent equilibrium, but instead adopt a flexible and "opportunistic" approach, applying specific management tools when faced by changes caused by natural events. This way of analysing environmental change on rangelands in Botswana has been applied by Abel (1992, 1993) and De Queiroz (1993). The concept is particularly useful when seeking the differential impact of natural and man-made causes (see e.g. Biot 1993, Scoones 1993, Tapson 1993). However, it should be noted that the model tends to be interpreted differently by different authors (Dahlberg 1993a).

On the basis of the theories underlying the state-and-transition model, additional concepts and methodologies are being developed. For example, Friedel (1991), taking into account that the environment fluctuates between a number of states, has developed a concept of thresholds of environmental changes. Certain combinations of events may push the environment over a threshold to a state that is not, without substantial management interventions, reversible on a practical time scale. That is, the environment enters a more degraded state. Two thresholds are described for arid and semi-arid rangelands; one separates grassland from woodland, and the other, stable from degraded soil. The latter is reached when soil erosion outstrips replenishment and physical and chemical soil properties are irreversibly altered. Friedel suggests a method of monitoring how near the environment is to a threshold, and outlines how natural effects can be separated from...
those due to management practices. In this context multivariate analysis is seen as a valuable tool. Bosch & Kellner (1991) combine this with a model using a degradation gradient for the ecological interpretation of environmental condition assessments of grasslands in South Africa.

It should be noted here that opinions differ concerning what state(s) should be described as degraded. For example, in North-East Botswana, we found that the transition from grassland to woodland (in this case dense thornbush) does not indicate degradation (Dahlberg 1993b). Findings by Perkins & Thomas (1993) on vegetation changes in grazed areas of the Kalahari can be interpreted in a similar vein. The importance of such environmental characteristics as resilience and stability, coupled to factors such as sustainability and productivity in the assessment of land use systems, are further explored in Walker & Noy-Meir (1982), Conway (1987), Conway & Barbier (1990), Goodland (1989), Brookfield (1992) and Behnke et al. (1993).

The concept of carrying capacity

In a handbook on ecology for range management in Botswana, Field (1978) states that by adopting proper grazing practices, one can ensure that the range is kept in optimum condition. In the context of maintaining such an equilibrium, the method for measuring carrying capacity is described, and held forth as one of the more important tools in range management. Carrying capacity is defined as "the correct stocking rate for a given area... [so that the animals]...can be maintained and produce efficiently (milk or beef) without deterioration of the natural resources of that area" (ibid. 89). This is an example of how the concept of carrying capacity has traditionally been defined and used in semi-arid areas of Southern Africa. The concept is based on successional theory of ecology, and employs methods originally designed for cattle ranching in North America (Abel 1992). Recently, the methodology used, as well as the underlying theories, have been contested as being inappropriate for African conditions. Also, a recent study argues that this classical approach is often inappropriate even for North American conditions (Gilles & Gefu 1990).

The concept of carrying capacity has had a great impact on research, project design and policy formulation for the semi-arid rangelands of Sub-Saharan Africa (Abel 1992). Large tracts of rangelands have been assessed, resulting in detailed management schemes which usually include stocking rates and rotation of land under grazing. However, Bartels et al. (1993) show how confused the issue has become. Many definitions of carrying capacity exist, and these vary depending on whether the primary interest is livestock production, resource conservation or wildlife management. Focusing on livestock production, one finds that definitions still vary depending on different management goals. As Abel (1992) and White (1993) have shown for Botswana, and Scoones (1992b) for Zimbabwe, an owner of a small herd on communal land would measure carrying capacity very differently from the commercial rancher or the Government officer.

Hendzel (1981), discussing the situation in Botswana, maintains a successional
approach, but argues for a careful use of the carrying capacity concept. "Grazing capacity is often difficult to determine. Variable weather causes great fluctuations in the amount of forage produced from one year to the next. Livestock distribution is another important factor in determining grazing capacity" (ibid. 6). De Leeuw & Tothill (1990) critically examine the difficulties inherent in applying the classical approach of carrying capacity estimates to the semi-arid environments of Africa. For example, carrying capacity is often treated as a static factor, whereas the environment will vary in space and over time. Fodder availability will change over the year depending on rainfall, and livestock will utilise different niches within the ecosystem depending on season and needs. In communal areas grazing areas are not delimited, a basic assumption of the carrying capacity concept. Also, carrying capacity is often calculated according to the needs assumed for cattle, while many pastoral and agropastoral systems keep animals of different kinds, often in mixed herds. However, in spite of the many limitations, earlier errors and misconceptions, de Leeuw and Tothill (ibid. 16) come to the conclusion that the concept of carrying capacity is useful, and that "the underlying principles on which it is based need full acceptance, without which no sustained resource management can be accomplished".

However, this conclusion has been contested by others. On the basis of studies conducted in Zimbabwe, Scoones (1989a) discusses the difference between "economic carrying capacity" and "ecological carrying capacity". The latter is what the environment can hold without density-dependent death of animals and/or irreversible deterioration. The former is the number of animals that offer maximum economic return determined by the specific objectives of the producer. He claims that the economic carrying capacity is often much higher for communal areas than that for cattle ranches, and that it is rational for subsistence farmers to bring their herds close to ecological carrying capacity. The fundamental issue is that, according to ideas on disequilibrium ecosystems (see e.g. Behnke et al. 1993), we do not know at what point ecological carrying capacity lies (Scoones 1993). Environmental factors traditionally used to describe states of overgrazing are now often rejected as reliable indicators of degradation (Scoones 1989b for Zimbabwe, de Ridder & Breman 1993 for the Sahelian countries, Perkins & Thomas 1993 for the Kalahari). Further criticism is forwarded by Bartels et al. (1993: 100), who state that it is "virtually impossible to estimate [carrying capacity] accurately, and that the concept cannot be applied in pastoral systems, except perhaps in special circumstances where animals are confined to rangeland, their mobility is restricted and there is relatively little variation in forage production". These conditions hardly apply to any range in Africa.

Bartels et al. (1993) instead suggest that an approach based on monitoring should replace traditional estimates of carrying capacity. Hereby, declines in long-term livestock and forage production, or in infiltration capacity, or an increase of soil erosion, can be detected. A similar approach has been advocated by Behnke (1992) in a review of studies from Southern Africa. Recognising the rationale of opportunistic strategies traditionally employed by pastoralists and other subsist-
ence cattle owners, Abel & Blaikie (1989) suggested a tracking strategy where cattle are removed from the range when forage availability declines. This can be achieved by selling the cattle through organised market outlets (Behnke 1992), or by moving them to other pastures. In times of severe drought large-scale movement occurs, whereas the spatial heterogeneity of the nearby environment is utilised when seasonal variability causes fluctuations in forage production (Scoones 1989b).

**Savoy's model**
The Holistic Resource Management (HRM) model described by Savory (1988a) has strong links both with theories of carrying capacity, and with ideas about non-equilibrium ecosystems, and is thus a special case. This model is intended for research, planning and management of ecosystems in general, but is today mainly used on rangelands in the USA. However, the model was developed on the basis of work in Zimbabwe and should, according to Savory, be equally appropriate there.

In brief, Savory emphasises a holistic approach to the management of ecosystems, where the appropriate management tools are fire, rest, grazing, animal impact through trampling, wildlife, technology and human creativity (Savory 1988a). He distinguishes between brittle and nonbrittle environments, where the former are more susceptible to erosion and degradation. In a brittle environment, characterised by unreliable precipitation, a variable growing season and a slow breakdown of organic material, the effects of grazing and resting are dramatically different from what they would be in nonbrittle environments. If a brittle environment is rested from physical disturbance like grazing, species diversity and stability will decrease; or in Savory's words, "inadequate animal impact combined with overgrazing has a very adverse effect on the ecosystem — much more adverse, in fact, than does overgrazing on its own" (Savory 1989). Animal impact (trampling, urinating, etc.) creates favourable environments for plant germination and can thus offset at least some of the negative impact of overgrazing (Savory 1988b). If animal impact is allowed under controlled forms, vegetation cover increases and a more stable system is maintained. On the other hand, in nonbrittle environments, which are more common in the temperate parts of the world, rest from disturbance is considered to have a beneficial effect (ibid.).

Bayer et al. (1987), while admitting that several of these theories are worth testing, is of the opinion that the model does not hold as a general principle. More specifically, Savory's ideas have been most strongly contested concerning the applicability of his ideas on African pastoral and agropastoral land use systems. For example, it is recognised that many systems are not easily categorised as either brittle or nonbrittle, especially when viewed over the different seasons (ibid.). Also, the influence of culturally derived perceptions of environment and management, as discussed by Abel (1992) in the context of carrying capacity models, is of interest here. To translate a model developed for North American cattle ranches to conditions specific for communal areas in Southern Africa is not easily done. It should also be noted that even for conditions in North America Savory's ideas are quite controversial.
The debate on environmental change and degradation in Southern Africa is characterised by changing and contesting views. In part this is a reaction to the number of different research approaches that have been employed over the last decades. Some of the more important trends will be examined here. The examples are mainly chosen from research in Southern Africa, but in some instances studies from other areas are used.

During the colonial rule, environmental research in Africa was mainly concerned with finding profitable ways to exploit the natural resources (Stocking 1992a). During the latter half of the century, resources were also invested in reducing land degradation that was blamed on the traditional land use practices of the local farmers and herders (Fairhead 1992). With these objectives vast amounts of environmental data were collected, mainly by natural scientists (Stocking 1992b), while social scientists pursued their research separately.

An interdisciplinarity approach

Over the last two decades recognition has grown that studies on land degradation must include an understanding of social, economic and political factors (Christiansson 1981, Blaikie 1985). In spite of this, interdisciplinary studies are not common, and further integration is strongly advocated (Hjort af Ornas & Salih 1991, Darkoh 1993). An awareness of the impact of employing different levels and scales should also be included in an interdisciplinary approach (Blaikie & Brookfield 1987a). However, arguments based on a combination of research conducted on different scales and within different disciplines, are difficult to verify (Conway 1987). This lack of conventional scientific "proof" makes proposed, sometimes radical, solutions less likely to be accepted by academic institutions, funding agencies and governments (Christiansson et al. 1993, Stern 1993). However, at least some donor agencies now accept the idea of interdisciplinarity, both in terms of the expert personnel involved and in advocating the "...acceptance of the land users' perspective as the basis for local planning" (Lundgren & Taylor 1993: 31).

Especially since the 1970s, land degradation issues have been linked to the discussion of sustainable development, which strongly emphasises problems of poverty, inequality and political instability as the major factors ultimately governing processes of natural resource depletion (WCED 1987, Goodland 1989, Darkoh 1993). In several countries in the Sahel the links between security and environmental degradation have been extensively studied, both at the local and
national level (Hjort af Ornas & Salih 1989, 1991, Hjort af Ornas 1992). For some of the arid parts of Kenya, Oba (1992) has described how environmental degradation is both cause and result of land use conflicts. Also in Southern Africa, especially in countries such as South Africa, Mozambique, Angola and Zimbabwe, issues of security and environmental degradation are closely linked.

In some areas more long-term projects, involving many scientists from different disciplines, are being conducted. As mentioned above, social and natural scientists have come together to conduct a multidisciplinary study of the Machakos District in Kenya covering a 60 year period. A number of aspects, from rainfall and soil erosion to farming systems and local income, have been combined by a team of scientists (Tiffen et al. 1994). In the arid region of central Tanzania, a multidisciplinary research project, with local and foreign scientists, is looking at land management and land degradation issues. The aim is to reach a deeper understanding of the processes involved, as well as to develop techniques needed for this kind of study (Christiansson et al. 1991). A study covering aspects such as cattle-keeping, ecological change and communal management was conducted in southern Botswana. This project was a joint venture involving both scientists and government personnel (Abel et al. 1987).

**Problems of accuracy and scale**

Over the last decade criticism has accumulated concerning the alleged accuracy of assessments of environmental degradation. Many authors are especially concerned about some of methodologies traditionally used, and how data are extrapolated from one area to another, and from one scale to another. Examples abound from many geographical regions of how so called 'objective hard data', analysed with complex statistical methods, have resulted in descriptions and analysis that are grossly erroneous (Chambers 1983, Gill 1993). Especially when used in policy formulation, these results can be very misleading.

Stocking (1987) presents a striking example of how several different studies, all aiming to show the extent and degree of desertification in Africa, and utilising the same database, came up with extremely divergent results. One reason for this is that the national statistical databases, which are based on country-wide surveys, often contain large errors. The data are not as objective as they are often presumed to be. Gill (1993) presents an unusually illustrative example of this, based on a research in Nepal, while Proctor's study from Swaziland reveals similar errors (Proctor 1990). Small-sample surveys, or site-specific physical measurements, all too often contain inaccuracies which make the results less useful (Carpenter 1989). The representativeness of results in time and space is a problem that seldom is taken into account. Rydgren (1993) demonstrates both the need and the difficulties of this when applied to studies of soil erosion and conservation. Fienberg & Tanur (1989) are quite drastic in their judgement, stating that, until researchers start taking measures to counteract this kind of errors, their results cannot be taken seriously.
Concerning type and scale of studies on land degradation in Africa, the late 80s and the early 90s have seen a profound shift in approach. Stocking (1992a) states that:

A major change has been away from large, multi-site erosion research projects towards more specific, focused trials with well-defined and sometimes quite modest objectives. No doubt this is a change partly forced upon researchers by funding constraints. Nevertheless, it is a trend which recognises the very site-specific nature of resource management in Africa, where (a) the environmental conditions provide a unique set of opportunities and constraints, and (b) the social, economic and political circumstances of local people, local leaders and decision-makers combine to ensure that no universal solutions can operate (ibid. 15).

The ongoing study in north-eastern Botswana (Kinlund 1991, Dahlberg 1993b), is one example of research whose approach comes close to the above description. However, even site-specific research implies a choice of scale, and it is seldom obvious which, if any one, gives the most relevant results. On the basis of studies of erosion processes in Lesotho, Rydgren (1993) demonstrates that results reached by studying the same processes even at different local scales, may still differ substantially. By incorporating these findings in the final analysis new insight are gained.

Economy

Another domain of environmental research that is gaining influence is that of ecological economics (Biot et al. 1993). At some institutions, (e.g. the Beijer Institute in Stockholm), this subject has become an independent discipline, with a research approach aimed at both developed and developing countries.

A tool that has become more common in research on environmental change and degradation is cost-benefit analysis. Very simply, this is the analysis, in monetary terms, of what continued degradation of natural resources will cost, in contrast to an investment in conservation practices. This approach can be used at different spatial scales, and is claimed to "identify the underlying causes and significance of degradation" (Chou & Dregne 1993:20). The methodologies involved are neither simple nor straightforward. For example, no accepted rules exist for measuring the monetary worth of such commodities as fertile soil, clean air and water, and longer life-expectancy.

Bojo (1991) has made an extensive and detailed study of the economics of land degradation, applying his theories to the situation in Lesotho. Using theories of economy in an applied and interdisciplinary manner, he aims at assessing the significance of land degradation, as well as understanding the causes and suggesting possible remedies. This work is also an example of the benefits inherent in studying the issue of degradation at different spatial and social scales, applicable at both the national and the project level. In Zimbabwe, Scoones (1992b) has conducted a cost-benefit analysis for livestock in different ecological zones. His findings, of relevance to the overgrazing debate in Southern Africa, indicate that communal livestock herding gives higher returns from the land than does commercial...
ranching. Similar conclusions have been presented in some recent research from Botswana (Abel 1993, White 1993). A quantitative analysis of the costs and benefits of environmental degradation and conservation measures respectively, is important for the design of policies and projects (Bishop 1992). An economic analysis is equally important when discussing issues of sustainability and productivity (Conway & Barbier 1990). Quite generally, more effort is necessary in order to establish the many linkages between economics and environment (Goodland 1989).

**Indigenous knowledge and perception**

Whereas earlier, the study of indigenous knowledge systems and traditional land use practices was conducted solely by anthropologists, it has now come to be seen as a valuable source of information for scientists from many disciplines (Richards 1985, Fairhead 1992, Stocking 1992a). The study of indigenous knowledge systems is much more than the collection of beliefs and practices. It has been a valuable contribution to many types of studies, of e.g. biodiversity (Gadgil et al. 1993), agricultural systems (Richards 1985), pastoral land and livestock management (Gilles 1982, Coughenour et al. 1985, Oba & Lusigi 1987), and soil conservation and sustainable land use (Rydgren 1993).

Two main approaches to these studies have emerged. The first is concerned with the interpretation and empirical analysis of the validity of indigenous beliefs and practices within the conceptual mode of western science. The second deals more with the challenge to western ideas posed by the cross-cultural study of indigenous ecological belief systems. Here the study of indigenous knowledge systems is more concerned with comparisons than with evaluation (Fairhead 1992). It should be emphasised that it is not enough to study what people do, one must also understand why they choose a particular strategy at a particular time (Stern 1993). Studies on decision-making among local people have been undertaken for example in pastoral communities in Africa (Niamir 1990).

Scoones (1989b) has included interviews on traditional practices and ecological knowledge systems in his study of the environmental impact of grazing in Zimbabwe. Because of this, Scoones conclusions differ considerably from other studies of grazing management in Zimbabwe. In Zambia, Stromgaard (1989) studied effects of changing land use practices, specifically the breakdown of traditional shifting cultivation, and included a survey of the strategies utilised by farmers to cope with the changing circumstances. From Kenya there exists a number of studies, especially of the pastoral groups, covering aspects of ecological knowledge and traditional strategies and land use practices (e.g. Homewood & Hurst 1986, Homewood & Rodgers 1987). Østberg (1991) has studied local beliefs in relation to land management and land degradation in Tanzania.

An issue that is gaining more recognition is the influence of the different perceptions of the environment that can be ascribed to different groups in society. Traditionally the scientist was accepted as an objective observer, and the fact that local people, and even different groups within the local community, held divergent
views was seldom recognised (Jungerius 1985, Stocking 1992a). Already in the late 1970s UNESCO, as part of their Man and the Biosphere Programme (MAB), published guidelines for field studies on environmental perception (Whyte 1977). This is an essential source of information in applied environmental research, and has for example been employed for studies on how people tackle drought situations (Heathcote 1991).

In Southern Africa, with many researchers engaged in conservation issues, a few have included the aspect of perception in order to compare how these questions are acknowledged and addressed by different groups of local people (Hackel 1990, Hunter et al. 1990). In Lesotho, understanding of the causal links of soil erosion over time was enhanced by interviewing local people about their perception of the past and present situation (Showers & Malahleha 1992). In Botswana this aspect is included in a study of environmental change and degradation (Dahlberg 1993b and in prep.). Fortmann (1989) has demonstrated the diverging perceptions of local people and of colonial and government officials, and shown how this has affected land management interventions in Botswana. A study by Gay (1984) revealed the rationale of subsistence farmers in Lesotho concerning their attitudes to soil erosion and soil conservation. On the basis of experience from Lesotho, Rydgren (1993) discusses the importance of acknowledging the socio-economic environment of the different decision-makers involved, i.e. what determines their perceptions and attitudes. With this approach, studies of soil erosion and conservation may become not only more accurate, but also more useful.

Surveys

Survey techniques have varied, following trends set in the interface of academic research and project implementation. In the late 1980s so called ‘rapid rural appraisal’ (RRA) became common (McCracken et al. 1988), fashioned in accordance with ideas of participatory research (Chambers 1983). Today RRA is being replaced by a similar technique, participatory rural appraisal (PRA) (IIED 1991). In short, these methods were designed by and for social scientists, in an effort to avoid the top-down approach common in traditional studies of indigenous land use practices. They are less time-consuming and cost less than traditional methods of collecting baseline data. They also have the advantage of being flexible and thereby more suitable for use within different disciplines (McCracken et al. 1988). Stocking (1992b), for example, recommends a similar approach for the assessment of physical factors. However, it must be remembered that what one gains in terms of time and resources, one might lose in accuracy. Scientists applying RRA and PRA should have experience of the particular community under study, and be aware of the inherent shortcomings of the methodology (Lindberg et al. 1993).

In Lesotho interview surveys have, for example, been used in historical assessments of soil degradation (Showers & Malahleha 1992), in research on erosion processes and the effects of erosion (Turner 1979, Bojo 1991), and in evaluations of institutional approaches to issues of erosion and conservation (Dahlberg
Fig 4
Leribe District, Lesotho. Members of a village cooperative. The inclusion of their knowledge of plants, soils and local climate variation changed the scope of the development project operating in their area, and improved its applicability.

In Zimbabwe, Scoones (1989b, 1992c) has used surveys when interpreting environmental condition and change on communal rangelands. For Botswana, studies of erosion and rangeland degradation are numerous. Most of these are only concerned with physical data, but recently interview surveys and statistical records have been employed in order to broaden the scope and increase the depth of the study. The physical scientists have mainly used surveys as a tool for checking and increasing the information obtained through biophysical methods (Biot 1988, Arntzen 1989, Abel 1992, Dahlberg 1993b), for others it constitutes a main part of the fieldwork (Kilund 1991), while yet others have adopted an integrated approach where interview surveys are given the same value as other methodologies (Barnhoorn & Riezebos 1991).

The increasing use of surveys, also by other than social scientists, is a valuable addition to studies of environmental change and degradation in Southern Africa. However, designing and conducting surveys is not a simple procedure, and the risk for errors increases when untrained people utilise this source of information, either in conducting their own surveys, or analysing data collected by others (Gill 1993).

Remote sensing and large-scale databases

An interest in local situations and small-scale coverage is inherent in several of the approaches described above. In contrast, the use of remote sensing techniques and
geographical information systems (GIS), can cover very large areas, especially when based on satellite imagery. The development of these techniques has been rapid, and is likely to continue (Justice 1986). In Africa they have mainly been used for land degradation assessment and classification of land cover. For example, Malo & Nicholson (1990) have demonstrated the use of satellite imagery for reconstructing rainfall patterns. This could be used for monitoring and quantifying desertification in semi-arid regions, and would be especially valuable where conventional field measurements are sparse or unreliable. However, similar studies have turned up anomalies in the data-sets (Nicholson et al. 1990), and others have demonstrated difficulties which would necessitate a number of technical and scientific improvements (Tucker et al. 1985, Verstraete & Pinty 1991). Barrett & Hamilton (1986), conclude that satellite data so far have been used in a very "fragmentary and unsystematic manner" (ibid. 167), partly owing to the patchy, variable and incomplete character of the spatial, spectral and temporal coverage. In spite of many improvements, lack of long time-series is still a problem in semi-arid Africa.

In Southern Africa the use of aerial photographs has so far been more common than satellite imagery. It is considered a useful and accessible technique, and handbooks have been produced in order to adapt these technologies for the environmental characteristics of the region (see e.g. Larsson & Stromquist 1991). In a study from Botswana, Ringrose (1987) set up a hierarchical land-cover classification system in order to monitor degradation signs at different spatial scales. She compared aerial photographs of an area around Gaborone over a time period of a few years and found signs of increasing degradation. However, in these studies the value of any conclusions on degradation are doubtful, due to the short time period involved (Abel 1992).

In Botswana different types of remote sensing techniques based on satellite imagery have also been tested and used for a variety of purposes. Ringrose and Matheson (1986) studied images from 1982 and 1984 with the aim of detecting and monitoring signs of rangeland degradation. Satellite imagery, both Landsat and NOAA data, have been used in methodological trials concerned with the monitoring of herbaceous cover on rangelands (Prince & Tucker 1986, Prince & Astle 1986). The main purpose was to assist range management decisions on a district and national level. However, a lack of understanding of the factors that affect vegetation changes made it difficult to use the results for recommendations or predictions. In addition, because of the extreme temporal and spatial heterogeneity in vegetation cover and biomass in these environments, different vegetation types have to be examined individually, and extrapolating between them must be avoided (Prince & Astle 1986). Van Heist (1991) used Landsat MSS data for a study of woody cover and biomass estimates in parts of Botswana. In a critical evaluation she concludes that the usefulness of such data for this particular type of study is limited. She stressed the need for test-comparisons with studies based on other kinds of satellite data, and discussed the influence of sampling time and different field work procedures. She also concluded that for semi-arid areas it is
imperative to improve the methods for estimating cover and biomass. An evaluation of the use of SPOT satellite imagery for planning and inventories of land resources in Lesotho discusses the benefits of this and other remote sensing techniques (Stromquist et al. 1988). However, the authors stressed the importance of integrating different techniques, of adapting them to local conditions, and of the user having a good knowledge of the social and physical characteristics of the area under study.

That remote sensing techniques, including GIS and spatial modelling, are valuable tools for studies of semi-arid environments is seldom questioned. However, opinions differ concerning how they should be applied, especially in studies on land degradation (Barrett & Hamilton 1986). For example, some stress the need to correlate, and complement, remote sensing data with national statistics, as well as with biophysical and socio-economic field data (Helldén 1991, Grunblatt et al. 1992). Without this additional information there is a risk to write off whole areas as being utterly degraded, ignoring the variability of the environment and the fact that people still live there (Olsson 1992). Discussing the potential value of using satellite remote sensing in studies of arid lands processes, including land degradation, Verstraete & Pinty (1991) conclude that these problems "...must be studied with the appropriate conceptual and mathematical tools" (ibid. 61). To them degradation, and the technical aspects of using remote sensing in studying these processes, seems purely a bio-physical problem. On the basis of their study, they claim that overgrazing and inappropriate agricultural practices are the causes of land degradation, a conclusion strongly questioned by others.

Remote sensing techniques are often used in combination with large modern databases. For example, global soil and climatic databases have been used in the compilation of a world atlas of desertification (UNEP 1992). A study from semi-arid Africa is presented by Thomas & Middleton (1993), who used the UNEP programme for the Global Assessment of Soil Degradation (GLASOD), with data stored and analysed on the Global Resources Information Database (GRID). The authors claim that this programme allows the evaluation of land degradation at different scales, for different regions, and by different causes. Others, while admitting to certain benefits, stress the risks inherent in this approach (Warren & Agnew 1988, Gill 1993). These are of a similar nature to those discussed above, thus, they emphasise the need to integrate large-scale surveys with local information.
7. Summary and Discussion

Why embark on a next to impossible task? Innumerable books, articles and reports have been written on the subject of degradation and environmental change in Southern Africa. To write a literature review of a subject as vast as this is to invite criticism concerning the approach taken, the topics and views presented and the references selected. When, as here, the aim is to review contesting views and changing paradigms, the subjective choice of contents, as well as of what is left out, sets a personal mark on the text that is not always encountered in a review.

The topics discussed in this review are numerous, but many relevant issues have been left out or mentioned only briefly. For example, the effect of tenure on environmental change and degradation, and the use of environmental impact assessments, are two important aspects of the debate that this review only alludes to. These and other omissions are due to the necessity of limiting the scope and size of the text, and are not the result of any value judgements. Similarly, although the reference list is long, many valuable studies have been left out. What we hope to have achieved is a summary of approaches adopted, of the type of conclusions presented, and an overview of the contradictions and conflicts of the debate.

Why an emphasis on Southern Africa?

Degradation of drylands occurs all over the world, not only in Africa, or in developing countries in general. The Great Dust Bowl in the United States in the 1930s threatened large areas (Goudie 1981), and the environmental problems in North America are far from solved (Lubchenco et al. 1991). In the dryland regions of the former Soviet Union evidence of extensive land degradation is accumulating (Alayev et al. 1990). Dryland degradation is definitely not only the concern of the developing countries, but here it does attain a higher degree of urgency. In Southern Africa the majority of the population are dependent on their local environment, a situation not as often found in the Northern Hemisphere. In countries like Botswana, Lesotho and Zimbabwe this is changing, with more people being drawn to the towns and to formal wage employment. However, according to many observers, this change might not occur as swiftly as has been expected, and for some time to come millions of people depend on their hectares of arable land, and on the communal grazing areas next to their villages.

Contesting views

How should dryland degradation be defined? If it were not for the impact created by statements on degradation issued by governments and international organisa-
tions like the UN, a large part of section two of this paper could easily be disregarded. However, that impact exists, and it not only steers funding in specific ways, it also affects the views held in the scientific community as well as by policymakers world-wide. Depending on local characteristics and temporal variability, environmental change can take on many guises, and an assessment whether land degradation (in a fundamental sense) has occurred cannot be determined by a straightforward application of a few clear-cut criteria. Simplified definitions cannot accommodate the heterogeneity that is typical of the drylands of the world. It is necessary to go a step further and try to take into account the linkages between the processes involved. The definitions formulated by Abel and Blaikie (1989) and by Biot (1991a) are examples that go beyond physical characteristics. Degradation cannot be measured as area of bare ground, or in number of dead cattle. One must include physical changes over a long time period, the socio-economic and cultural changes in local communities, and the interactions that occur between these and other levels of society.

The use of degradation indicators is but one example of the risk of over-simplification. This review argues that indicators, whether bio-physical or socio-economic, should be discussed in a local context, and within a time perspective that is compatible with the emerging ecological theories for semi-arid environments. This is equally relevant in the search for causes of degradation, (cf. the discussion and examples presented in section three and four). Concerning the theories of non-equilibrium described by Behnke et al. (1993) and others, this review finds much in favour of these new, or renewed, ideas. However, in creating a forum for a re-evaluation of past "truths", the promoters of this "new paradigm" themselves run the risk of simplifying and generalising. As stressed before, environments and communities vary, and although the degree of degradation certainly seems to be exaggerated for many areas, in other regions the threat is quite real (Galaty & Johnson 1990).

Concerning the discussions on aspects of time and space presented in section five, the implication is not that every scholar studying the environment of Southern Africa should recreate the paleoenvironment of each study area. However, much can be gained by some knowledge of past environments, climate and land use, and an interdisciplinary approach that is at least aware of these aspects is strongly advocated. In environmental research, as in many other fields, it happens all too easily that a project, and the analysis of the results, are carried out with a vision clouded by unacknowledged preconceptions and biases. One can never eliminate this risk completely, but it should be the responsibility of every scientist to try to minimise it. (Compare our introductory quotation from Chamberlin (1890)).

This is equally important in studies of present conditions. When studying land degradation one needs to be aware of the heterogeneity of the semi-arid environment. Rainfall is extremely variable over short distances, and vegetation types occur patchwise, owing to spatial differences in bedrock and hydrology etc. Local land use is adapted to these variations in space and over time, and this is a further reason to seek understanding of the hierarchy of processes involved in the management of local resources.
Hardin’s theory of the "tragedy of the commons", i.e. that on communal land every individual strives to maximise his or her own short-term profit, without caring about the future of the resource base (Hardin 1968), started a debate that is still far from settled (Mace 1991). Traditional land management practices, which were considered harmful to the environment, have been re-evaluated, and are often found to be more appropriate than those advocated by foreign agencies and governments. On the other hand, because of increasing poverty, migration and conflicts, many local institutions set up to enforce control over the utilisation of natural resources have broken down. In many areas people either lack the appropriate knowledge, or are unable to practice what they know to be the more sustainable options.

Degradation or natural variation: is clarification possible?

This review does not take any general stand on exactly what constitutes degraded land, or if the situation is more serious in one country, or in one particular area, than in another. Every study should try to clarify what type of environmental changes have occurred and how these changes are perceived differently depending on how they will affect people directly and in terms of future productivity of the land. Factors of scale, level and hierarchy constitute a vital part both of theoretical models and for practical application in research and policy formulation (Blaikie & Brookfield 1987a, Conway 1987, Christiansson et al. 1993).

Whether the changes observed and/or measured are negative or not, is a question that should be treated with utmost care. If evidence of degradation is found, both scientists and project personnel should realise that "even in the face of profound degradation, [we] must guard against an attitude of extreme preservationist spirit" (Myers 1988: 3). Land that is degraded, or where such threats are imminent, cannot be abandoned or put aside as reserves. Concern for the environment must not be seen as a constraint development.

In this context an example from Botswana may serve to illustrate the thesis advocated in this review. Over time and between different sections of society the understanding of savanna ecology has varied and resulted in different management strategies. Policy makers, and most scientists, see soil erosion and a diminishing vegetative cover as severe forms of degradation. These changes are blamed on overgrazing, and stock reduction and resettlement are recommended as appropriate remedies. Farmers and cattle owners would describe savanna ecology and dynamics differently, acknowledging the variability of the environment. To them destocking is not only impossible from a cultural and economic standpoint, it does not even make ecological sense. By tradition they have utilised other strategies, e.g. the mobility of people and animals, to reduce the risk of degradation (Biot et al. 1993).

Research on environmental change and degradation must be developed as regards the understanding of the dynamics, ecological and social, that govern the drylands. However, even when we strongly believe that we know what we are doing, recommendations and regulations concerning land use promoted in the name of sustainability have to be reached through negotiations involving all concerned.
Acknowledgements

In the writing of this review I have been greatly helped by many colleagues and friends, not least in terms of keeping up my spirit when the load of literature seemed too large to cope with. I should like to thank Carl Christiansson and Wibjorn Karltn at the Department of Physical Geography, Stockholm University, for making useful comments at different stages. At the same Department, Per Syrttn and Katarina Perrolf gave me valuable advice in the early stages of writing, and Mats Eriksson and Lasse Westerberg were an encouragement simply by being there. At the School of Development Studies, University of East Anglia, I was warmly received and encouraged by all, staff as well as fellow students. The three months I spent there, much of it working on the present text, were inspiring and enjoyable. I owe special thanks to Piers Blaikie, Jim Sumberg and Jane Oliver, who read and commented on the disjointed drafts that were handed to them. Erling Dahlberg sacrificed weekends and evenings correcting language and logical errors, of which originally there were more than now. The remaining ones are solely the responsibility of the author.

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### Abbreviations

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<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>APRU</td>
<td>Animal Production Research Unit</td>
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<tr>
<td>AVHRR</td>
<td>Advanced Very High Resolution Radiometer</td>
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<td>BNA</td>
<td>Botswana National Archives</td>
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<tr>
<td>cf.</td>
<td>confer; compare</td>
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<tr>
<td>CFDA</td>
<td>Communal First Development Area</td>
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<td>EDSU</td>
<td>Environment and Development Studies Unit</td>
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<td>EEC</td>
<td>European Economic Community</td>
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<tr>
<td>EFI</td>
<td>Ekonomiska Forskningsinstitutet, Stockholm School of Economics</td>
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<tr>
<td>e.g.</td>
<td>exempli gratia; for example</td>
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<tr>
<td>et al.</td>
<td>et alii, et alia; and others</td>
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<tr>
<td>GIS</td>
<td>geographical information systems</td>
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<td>GLASOD</td>
<td>Global Assessment of Soil Degradation</td>
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<td>GRID</td>
<td>Global Resources Information Database</td>
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<td>HRM</td>
<td>Holistic Resource Management</td>
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<tr>
<td>ibid.</td>
<td>ibidem; in the same book or passage</td>
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<td>i.e.</td>
<td>id est; that is to say</td>
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<tr>
<td>IIED</td>
<td>International Institute for Environment and Development</td>
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<td>ILCA</td>
<td>International Livestock Centre for Africa</td>
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<td>INCD</td>
<td>International Convention to Combat Desertification in Countries Experiencing Drought and/or Desertification, Particularly in Africa</td>
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<td>IPCC</td>
<td>Intergovernmental Panel on Climate Change</td>
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<td>IRDC</td>
<td>International Rural Development Centre</td>
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<tr>
<td>ISAS</td>
<td>Institute of Southern African Studies</td>
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<td>ICSO</td>
<td>International Soil Conservation Organisation</td>
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<td>loc. cit.</td>
<td>loco citato; in the passage already cited</td>
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<td>MAB</td>
<td>Man and the Biosphere Programme</td>
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<td>MSS</td>
<td>Multi-Spectral Scanner</td>
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<tr>
<td>NIR</td>
<td>National Institute of Development Research and Documentation (earlier: National Institute of Development and Cultural Research)</td>
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<td>NOAA</td>
<td>National Oceanic and Atmospheric Administration</td>
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<td>ODG</td>
<td>Overseas Development Group</td>
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<td>ODI</td>
<td>Overseas Development Institute</td>
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<td>PDN</td>
<td>Pastoral Development Network</td>
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<td>PRA</td>
<td>Participatory Rural Appraisal</td>
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<td>RRA</td>
<td>Rapid Rural Appraisal</td>
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<td>SADCC</td>
<td>Southern African Development Coordination Conference</td>
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<td>SIDA</td>
<td>Swedish International Development Authority</td>
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<tr>
<td>SPOT</td>
<td>Satellite pour l’Observation de la Terre</td>
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<tr>
<td>TGLP</td>
<td>Tribal Grazing Land Policy</td>
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<td>UK</td>
<td>United Kingdom</td>
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<td>UN</td>
<td>United Nations</td>
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<td>UNCED</td>
<td>United Nations Conference on Environment and Development</td>
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<td>UNDP</td>
<td>United Nations Development Programme</td>
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<td>UNEP</td>
<td>United Nations Environment Programme</td>
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<tr>
<td>UNESCO</td>
<td>United Nations Educational, Scientific and Cultural Organisation</td>
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<tr>
<td>UNGI</td>
<td>Uppsala Naturgeografiska Institution</td>
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<tr>
<td>UNSO</td>
<td>United Nations Sudano-Sahelian Office</td>
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<tr>
<td>WCED</td>
<td>World Commission on Environment and Development</td>
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References

* - denotes relevant references that are not cited in the main text


Dahlberg, A., in prep.: Interviews as a tool in environmental change research: A case study from Kalakamate, North East District, Botswana. Department of Physical Geography, Stockholm University.


Gill, G.J., 1993: O.K., the data's lousy, but its all we've got. Being a critique of conventional methods. Gatekeeper Series No 38, IIED, 19p.


White, R., 1993: Livestock development and pastoral production on communal rangeland in Botswana. The Botswana Society, Gaborone, Botswana, 72p


Östberg, W., 1991: Land is coming up. Burungee thoughts on soil erosion and soil formation. Working Papzer No 11, Environment and Development Studies Unit, School of Geography, Stockholm University, 15p.
This study deals with issues of environmental change and degradation, with special reference to Southern Africa. Over the last couple of decades this debate has become quite heated. The aim of this paper is to clarify contrasting opinions, and to describe the more far-reaching shifts in scientific thinking. This is done by discussing definitions of the processes involved, the commonly used indicators and ascribed causes of degradation and the importance of time and space, especially in the context of the variability and heterogeneity which characterises the semi-arid environments. The value of interdisciplinarity is highlighted throughout the paper.

Annika Dahlberg is at present completing her PhD studies at the Department of Physical Geography, Stockholm University. Her thesis concerns changes in environment and land use in Botswana.