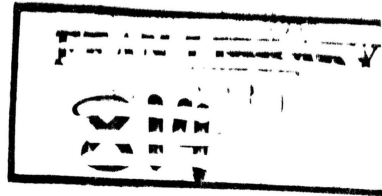


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GUEST EDITORIAL

Desertification and Namibia : a perspective

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Desertification is a complex problem and concept. This problem has ultimate causes, for example poverty, and proximate causes, such as agricultural mismanagement. These two levels of causation lead to processes, such as overgrazing or erosion, that manifest themselves in states of environmental degradation, for example eroded landscapes and annual in place of perennial grasslands. A sub-set of factors contributing to desertification are operative in Namibia, the driest country south of the Sahel. Namibia, with its rapidly increasing population, needs to develop an institutional memory of the consequences of natural rainfall variations. Awareness, education and training, based upon knowledge and understanding of the causes and processes involved, are considered essential components of any plan to address the challenge of desertification. This must be supported by research addressing, not just the symptoms of desertification but, the socio-economic agricultural, political and educational, in addition to biophysical, aspects. Bio-physical scientists working on desertification must learn to communicate with, as well as develop basic skills in, disciplines such as politics, economics, journalism and social science.

Désertification et Namibie : un point de vue. - La désertification est un concept et un problème complexes. Ce problème résulte de causes multiples, par exemple la pauvreté, et de causes immédiates telles que les pratiques culturelles. Ces deux niveaux de causes ont engendré des processus, tels que le surpâturage et l'érosion, qui se traduisent à leur tour par des états de dégradation de l'environnement, comme des paysages érodés de type annuel en lieu et place des pâturages pérennes. Un sous-ensemble de facteurs contribuant à la désertification opèrent en Namibie, le pays le plus sec au sud du Sahel. La Namibie, avec sa population qui croît rapidement a besoin de développer une mémoire institutionnelle des conséquences des variations naturelles des précipitations. Une prise de conscience, la formation et l'éducation, basées sur la connaissance et la compréhension des causes et processus mis en oeuvre, sont considérées comme des éléments essentiels de tout plan visant à combattre la désertification. Ceci doit reposer sur la recherche, une recherche étudiant, non seulement les symptômes de la désertification, mais aussi, outre les aspects biophysiques, les aspects socio-économiques agricoles, politiques et éducatifs. Les scientifiques qui pratiquent les sciences naturelles et travaillent dans le domaine de la désertification doivent apprendre à communiquer et à développer leurs talents, dans des disciplines telles que la politique, l'économie, le journalisme et les sciences sociales.

Key words : desert, overgrazing, erosion, Namib.

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INTRODUCTION

Desertification as a concept and environmental problem has received extensive attention during the latter half of the 20th century (e.g. Mainguet, 1991), although it has been experienced and documented in literature for millennia. The reduced productivity of the formerly 'fertile crescent' and the collapse of Roman granaries around the Mediterranean are two of the better known examples from history. In view of all the research and writing directed toward desertification in recent years, choosing desertification as the topic for a guest editorial may be questioned. However, our choice is based on the observation that, although we may have improved our understanding of the multi-faceted causes or processes leading to desertification, we have not increased our ability to alter, slow down or stop these processes. As we approach the twenty-first century, the manifestations and impacts of desertification are increasingly experienced over vast tracts of land on six of the seven continents. Renewed attention to this problem is being demanded by the governments of a number of affected countries following the Earth Summit held in Rio de Janeiro in June, 1992 (Anon, 1993a).

Desertification is a complex problem and even the terminology pertaining to desertification has been a matter of debate in recent years with 'desertification' and simply 'degradation' being recommended as more appropriate descriptors (e.g. Le Houerou, 1986, Mainguet, 1991). In most instances the terminology and definitions are used to encompass the concept of reduced productivity through degradation of soil and vegetation. However, in the past, and even in some parts of the world today, desertification has also implied the expansion of natural deserts, particularly sand dunes, into agricultural land (e.g. Zhu & Wang, 1993).

One of the early formalised definitions proposed by the United Nations Conference on Desertification (U.N.C.O.D.) described desertification as 'the diminution or destruction of the biological potential of the land, and can lead ultimately to desert-like conditions' (U.N. 1977). During the next decade, Dregne (1985) placed greater emphasis on the role of human activities referring to 'the impoverishment of terrestrial ecosystems under the impact of man'. Since the Earth Summit in Rio, the definition of desertification has been accepted as: 'land degradation in arid, semi-arid and sub-humid areas resulting from various factors, including climatic variations and human activities' (Cardy, 1993). Thus, today, the key role of the human component in desertification is clearly recognised. Although the vivid image of advancing sand dunes remains a dominant aspect of the popular lore, it appears that there are few dry areas where the working concept of desertification focuses on the expansion of desert sand dunes.

Even though human involvement in desertification processes is recognised, the bio-physical mechanisms of these processes still receive the majority of attention provided by media and politicians as well as researchers addressing the problem (e.g. Chouhan, 1992; Mainguet, 1991; Meckelein, 1980; Sen & Kar, 1993). Climate change and drought, and their impact and causative influence on desertification, remain a major focus for politicians and researchers alike. Loss of biodiversity associated with drought and desertification is receiving increasing attention (e.g. Tilman & El Haddi, 1992). As much desertification research concerns vegetation and soil changes on a macro scale, remote sensing is a major research tool (e.g. Pickup *et al.* 1993). However, to date, while the socio-economic causes of desertification, particularly population shifts and increases, are fully acknowledged (e.g.

Eckholm & Brown, 1977), they are rarely addressed by those in a position to bring about the necessary changes to halt or reverse desertification processes.

Despite a formal Plan of Action to Combat Desertification, initiated at the U. N. Conference on Desertification (UNCOD) in Nairobi in 1977, desertification continues to be a growing problem in the drylands of the world today. Part of the Plan's failure has been ascribed to the fact that it was never firmly placed in the international political agenda (Anon, 1993b). However, misdirected efforts to address the symptoms rather than the causes of desertification also appear to be a major factor.

A variety of causative factors leading to desertification are only now beginning to receive implicit recognition if not yet serious attention. These factors include the population explosion, particularly in Africa, raised expectations of people for a better life, influences of first world economic systems, changing political systems, altered or undefined land tenure arrangements, continued and increasing poverty, and media influences in shaping our concepts of these interacting factors. Our purpose in writing this guest editorial is to review some of the causes and processes of desertification as they relate to the driest country south of the Sahel. For although desertification has been recognised as a problem in Namibia (U.N.I.N. 1986), it is only since independence in 1990 that implicit actions and programmes are being designed that take into account the human component to reverse the processes involved. We anticipate that scientists reading the *Journal of African Zoology* will have broad firsthand experience with the African environment, and will thus provide comments and suggestions that will help Namibians avoid some of the more obvious pitfalls related to the study and control of desertification. We hope that this brief

review will contribute to establishing a dialogue that will facilitate the networking and interaction essential for addressing this major threat to the drylands of the world.

A NAMIBIAN OVERVIEW

In Namibia, as in much of Africa, the population is doubling at approximately 20 year intervals (the National Census of, 1991 revealed an estimated growth rate of over 3% per annum). This means that every 20 years, twice as many people are trying to make a living from the same amount of land and twice the amount of natural resources must be used to maintain the same standard of living. This population increase also means that twice as much arable land be cultivated and livestock raised, simply to maintain current standards. It is clear that even in a country with abundant rainfall and other natural resources, this rate of population and production increase cannot be sustained. In addition, increased expectations of people for an improved livelihood are a factor to be considered. By maintaining this rate of population increase, without making the necessary shifts to alternative livelihoods and sources of income, people are greatly increasing the susceptibility of their environment to desertification. All of the factors leading toward desertification in Namibia can be attributed, at least in part, to the rapid increase in population.

Namibia is the driest country in southern Africa (Fig. 1) (e.g. Marsh & Seely, 1992; Dealie *et al.* 1993). Low and variable rainfall is the consequence of the dry conditions that accompany Namibia's position on the continent and the globe. These conditions are reflected in the large geographical and temporal variations in Namibia's natural resource base (Fig. 2) (e.g. Brown, 1992; Seely & Louw, 1980; Louw & Seely, 1982). Within the constraints of Namibia's environ-

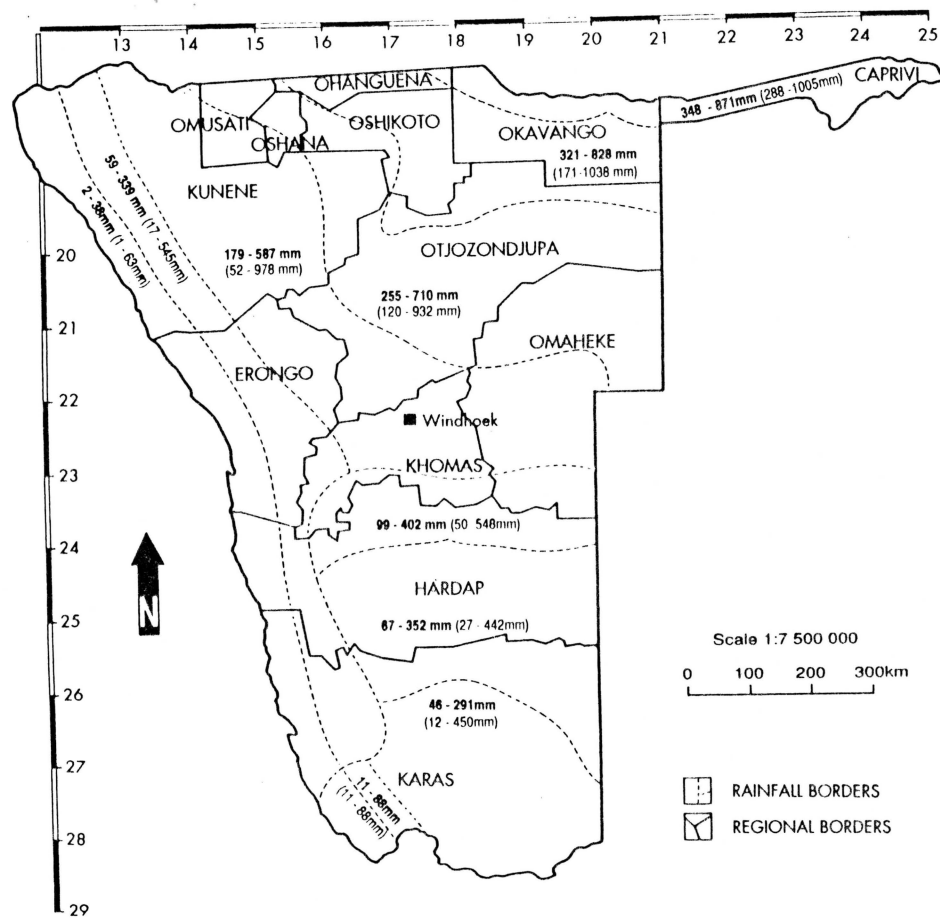


Fig. 1. - The mean range of rainfall, experienced in 95 % of all years for which records are available, is indicated for the various rainfall regions of Namibia (Dealie *et al.* 1993). The numbers in parentheses indicate the extreme values within the 95% range. Because of the small number of rainfall measuring points in the north and east of the country, these figures can be considered only as indications of the ranges to be expected.

ment, a limited number of farming systems are found (Adams *et al.* 1990; Office of the Prime Minister, 1992). In the northern, higher rainfall areas, mixed dryland farming on a subsistence level is the predominant system (e.g. Masdar, 1993; Tapscott, 1990). This involves cultivation of crops such as millet, sorghum and maize and livestock such as cattle, goats and donkeys. In the remainder of the country grazing systems predominate (e.g. Adams *et al.* 1990). A variety of supplementary incomes contribute to maintenance of these systems, for example, wage

labour, pensions, home industry, and household vegetable gardens.

In Namibia today, the naturally low and variable rainfall is thought to be a greater problem, which affects more people, than it did in the past. These perceptions are associated with increasing populations of people and domestic livestock and changing farming practices, livelihoods, life styles and expectations of people. At the same time, activities of people are exacerbating the negative effects of dry environments for humans and all living

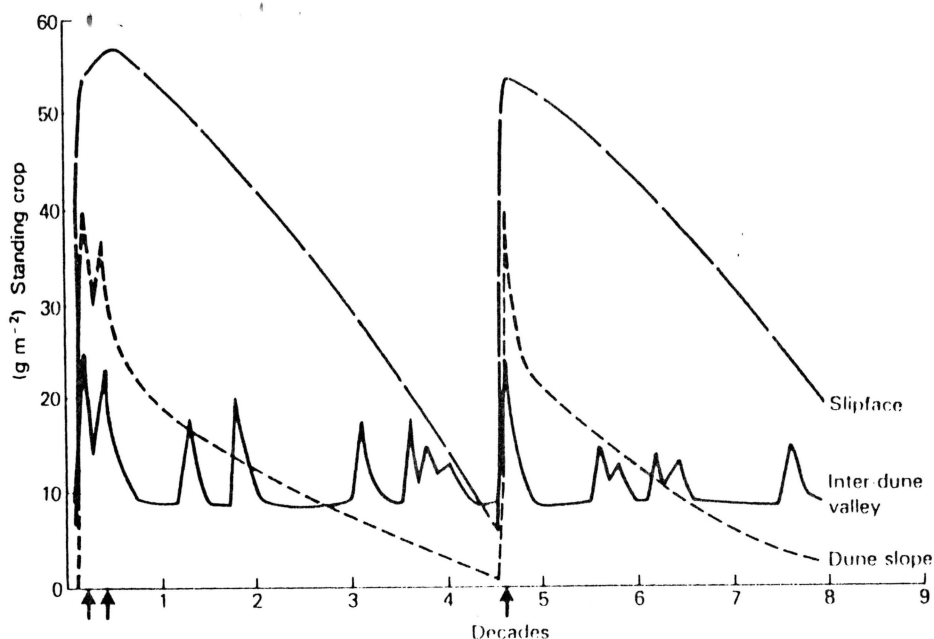


Fig. 2. - This simple model, based upon measurements of high and low biomass values measured in the Namib Desert of western Namibia (Louw & Seely, 1982), indicates the types of inter-annual variation of biomass that can be expected in an arid area. Similar variations would be expected in semi-arid or sub-humid areas, although the absolute values would differ from those portrayed. Such natural variation represents the major challenge for people attempting to make a living from drylands as well as for governments in dryland areas.

organisms. The reaction by government and individuals to one drought may, and very often does, fuel the ongoing processes controlling desertification. Is desertification inevitable in a dry country such as Namibia?

CAUSATIVE INFLUENCES OF DESERTIFICATION IN NAMIBIA

The ultimate causes of desertification, or degradation in arid, semi-arid and sub-humid environments can be roughly categorised as political, administrative, economic and social in nature and, in the long term view, climate change. On the other hand, the proximate causes include the bio-physical and land management factors more commonly associated with desertification, e.g. the climatic setting, that includes low and irregular rainfall, high evaporation and low groundwater

recharge and runoff, combined with inappropriate management practices. These proximate causes induce the processes of overgrazing, deforestation and salinisation that manifest themselves as reduction of productivity through erosion, loss of nutrients, increase in less preferred plant species, and general changes in ecosystem functioning.

Ultimate factors contributing to desertification

Desertification is mainly brought about by the immediate activities of rural people, and affects rural people most directly. Nevertheless, the activities of rural people are frequently orchestrated by persons well removed from and even unrelated to rural areas, i.e. urban-based people, local and foreign governments, and international agencies.

Direct and indirect affects of urban populations

People living in urban environments are engaged in a varied set of activities (Frayne, 1992) that can alter the susceptibility of the land to low rainfall and lead to desertification. In Namibia, many urban dwellers own livestock and in other ways influence, and often control, the activities taking place in the rural areas. Remittances from urban to rural areas assist people to cope with effects of drought (Naeraa *et al.* 1993.). However, they also may contribute to the perpetuation during high rainfall years of those activities that reduce the resilience of the environment during lower rainfall years. Moreover, most food consumed by the urban population comes from rural areas and this cost should be, but rarely if ever is, taken into account.

The demands of urban developments, for water, energy and food and shelter, all have the potential of increasing susceptibility of rural areas to the effects of low rainfall and resulting desertification. Lowered groundwater tables and removal of timber from remote areas are just two examples of this type of influence (e.g. Marsh & Seely, 1992). Meanwhile, because of infrastructure and services developed for urban areas, people living there are cushioned from the immediate effects of lower rainfall and land degradation. As a consequence, they are not as severely affected by desertification processes, nor are they as aware of their contribution to desertification.

National governments and economic policies

Throughout Africa, governments have a major influence on susceptibility of the land to desertification. Strongly centralised governments often neglect or ignore the needs and interests of the rural populace exacerbating the

processes that lead to desertification. Strong central governments tend to exploit their populace with the aim of concentrating wealth at the highest levels. Those governments in Africa with major debt repayment loads may encourage people to focus on, often inappropriate, cash crops or livestock production for the foreign market to the detriment of alternative land uses. When rainfall is low, however, both the cash crop and possibly any remaining food crops will fail, and animals in poor condition must be rapidly marketed or face death through starvation. All activities that increase dependence on a central government or foreign markets tend to increase susceptibility to drought and contribute to desertification (Dyson-Hudson, 1991).

Many aspects of the political framework of a country may contribute to, or be, the ultimate cause of desertification. The presence or absence of the political will to address very basic problems such as poverty, population increase, unrest, land tenure, artificial boundaries and host of similar factors can directly lead to desertification. Policies relating to development of many sectors of the government, or the absence thereof, can also induce desertification, for example, policies on energy, water, population and family planning, transport, manufacturing, and agriculture, amongst others. Marketing policies and facilities within a country may contribute positively or negatively to appropriate agricultural management practices and consequently desertification.

Government may also have a positive effect, particularly if it focuses on local solutions to problems induced by low and variable rainfall. Support of drought management strategies within the populace is also a positive influence that will slow desertification.

Within government, an absence of integrated planning covering the various

sectoral ministries may also be a major contributor to accelerating desertification. Very often, energy, water or transport developments contribute inadvertently but directly to agricultural mismanagement and desertification. For example in the area of Namibia formerly known as Owambo, canals and roads have been constructed perpendicular to the ephemeral water courses known as Oshanas. This reduces groundwater recharge, soil moisture and other potential benefits in downstream areas (Marsh & Seely, 1992). On the administrative level, uncoordinated activities even in the presence of appropriate planning may also contribute to degradation processes.

International and foreign donor agencies

Donors can influence the susceptibility of people and the environment to desertification. A major factor is a frequent lack of donor-donor coordination and donor-government coordination (e.g. Marsh & Seely, 1992). Focus upon one particular crop, activity, or solution to a problem, or on short-term drought relief rather than long-term sustainability, may reduce the diversity of responses normally used when rainfall is lower than expected. On the other hand, assistance with alternative livelihoods or development trajectories, that reduce dependence on the land and consequently low and variable rainfall, should reduce the rate of desertification.

In Namibia, the confusion of 'drought relief' with development has led to the hasty construction of numerous boreholes that will have long term negative effects in the absence of a shift to sustainable management practices (e.g. Goudie, 1981). Nevertheless, in Namibia at least one project addressing drought and desertification, based upon the complete involvement of the participating communities, appears to provide a model of successful develop-

ment and change (G.T.Z. 1991).

The media

The media have, in some instances, increased susceptibility of Namibians to drought and desertification, largely through their influence on decision makers and urban dwellers. In the popular media, drought is described as an unusual occurrence that requires emergency action, rather than emphasising that dry conditions and variable rainfall are the norm in Namibia and need to be planned for in advance. Such publicity implies that government intervention can be expected for drought rather than suggesting that every individual as well as the government should include it in their planning process. How low rainfall is perceived has a major impact on the coping and management strategies that are attempted or promoted during times of low rainfall and, consequently, on desertification.

Social or socio-economic aspects

Social or socio-economic aspects of a country may have the most profound effects on desertification. High population growth rates and lack of family planning and the associated poverty are often the major factors accelerating desertification. When people are living in poverty, even though they may realise the consequences of their mismanagement, they are not in a position to alter their own activities. Alternative life styles or livelihoods for the increasing population of much of the drylands of the world will be an essential component of desertification prevention or land rehabilitation. Desertification may also be caused, however, by people who are maintaining their wealth in the form of livestock or are farming with cash crops (e.g. Masdar, 1993). Raised expectations of persons with enhanced educational or financial status or enhanced access to information may also increase pressure on the land. All of these factors drive

desertification and none are being directly addressed within the context of desertification research.

A number of socio-economic factors stemming from the above ultimate causes have been identified as increasing drought susceptibility in Namibia (Seely *et al.* in press). These factors can or will contribute directly to the present or future processes controlling desertification. None of these factors or the activities they induce are unique to Namibia. They include:

- 1) increasing population of people and livestock,
- 2) wealth profile becoming more stratified,
- 3) change in demands from rural population on subsistence system,
- 4) change in valuation of subsistence system with increase in rural and urban populations and changing expectations,
- 5) reaction to drought rather than planning for drought,
- 6) acceptance and reliance on commercial crop economy with decreased use of traditional foods and arid-adapted subsistence patterns.

The ultimate causes of desertification, which deal specifically with people and their lifestyles and which require policy decisions and government action, are difficult to understand and, especially, address. Addressing these causes must happen in political, social and economic arenas, areas in which bio-physical scientists, the people generally addressing desertification, are not particularly skilled.

Proximate causes of desertification in Namibia

A number of specific land management activities resulting from the ultimate causes are contributing to the processes of desertification in Namibia. These activities include:

- 1) inappropriate provision of artificial

- water points,
- 2) sedentarisation of semi-nomadic and mobile human and livestock populations without concomitant shifts in management practices and livelihoods,
- 3) absentee farm management,
- 4) fencing under some land use management practices,
- 5) inappropriate crop cultivation practices.

Inappropriate provision of artificial water points

While desertification is associated with a reduced presence of water, there are two aspects of water availability. There may be reduced availability of drinking water for people and/or their domestic stock, required on a daily basis, or there may be reduced seasonal rainfall or water for irrigation influencing the interactions between vegetation, soil and water that provides food for people and animals. These two aspects, operating over different time scales, have been described as 'blue' water or drinking water and as 'green' water or that needed for growth of vegetation (Falkenmark, 1991). Frequently these two factors, water for drinking and water for food production, are not clearly differentiated, and this confusion in itself increases environmental susceptibility to and impact of the negative effects of low and variable rainfall.

Artificial provision of potable water alters the time scale of use in areas where water is normally limiting. Moreover, provision of drinking water during times of low rainfall, particularly to livestock, is a major factor enhancing the susceptibility of people and their livestock to future dry periods. This is induced by increasing the occupation duration of an area, thereby ensuring that overgrazing, bush encroachment and/or deforestation occur in areas not naturally subjected to continuous occupation (Marsh & Seely, 1992; EEAN, 1992a & b). By

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providing artificial water, more people
and livestock can live in an area, but a
greater negative impact on the environ-
ment is also promoted (e.g. Engelman &
de Roy, 1993; Falkenmark & Widstrand,
1992; Goudie, 1981; Thadani, 1990). The
social ramifications of altered access to
water and grazing through construction
of artificial water points (e.g., Toulmin,
1992), such as a shift from organised
control to free access, may also con-
tribute to desertification.

*Sedentarisation of semi-nomadic and
mobile human and livestock populations
without concomitant shifts in
management practices and livelihoods*

Dry areas have traditionally been
used on a nomadic or semi-nomadic
basis with permanent settlement usually
being restricted to perennial rivers and
oases (Kinahan, 1993). Nomadic
pastoralism represents adaptive mana-
gement (Westoby *et al.* 1989) taking into
account the continually changing
conditions of drylands environments on
an intra- and inter-annual basis. As the
ability to tap underground sources of
water and develop artificial water points
progresses, permanent settlements are
able to expand beyond their original
areas. Permanent grazing, cropping and
residence in certain areas, without the
input associated with adaptive mana-
gement, usually leads to a reduction of
the human and animal carrying capacity
which, in turn, leads to desertification.
Poverty and a shortage of labour in
communal areas are the usual exacer-
bating factors that make the influence of
sedentarisation negative in relation to
drought and desertification.

Absentee farm management

Absentee farm management is a
major factor contributing to the lack of
adaptive management, and hence
desertification in rural areas, particularly
on communal lands. This is a common
practice in Namibia where the women,

children and older people often remain
in the rural areas managing agricultural
activities of the family while the men
move to urban areas to obtain wage
employment (EEAN, 1992a). Despite
their absence from the farm, control of
many of the decisions concerning
farming rests with the men, negatively
influencing the way in which farm
management can be carried out.
Moreover, movement of the econo-
mically active segments of the popu-
lation away from rural areas leaves an
inadequate labour force available for
farming activities, despite increasing
population.

*Fencing under some land use
management practices*

Fencing of dry lands in Namibia, to
enhance productivity or define land
ownership, requires skilful mana-
gement. Fencing has the potential to
increase resilience of people and their
livestock to low rainfall or, alternatively,
to enhance desertification. Fencing that
contributes to unequal access and use of
communal pastures and fencing that
promotes long term, extensive grazing in
one area exacerbates desertification
(Office of the Prime Minister, 1991;
Marsh & Seely, 1992). On the other hand,
fencing that contributes to the adaptive
management essential in areas of low
and variable rainfall, will increase the
resilience of land and livestock. In the
absence of intensive adaptive mana-
gement, fencing inevitably reduces the
resilience of the ecosystem. Negative
consequences of this are experienced
directly by livestock on farms and by
wildlife in parks. In the latter instance,
people subsequently suffer from
decreasing tourism and availability of
alternative sources of food and income.

Inappropriate crop cultivation practices

Land managers must understand that
investment risk is very high for farming
activities in arid lands. The variety of

ways that people use the natural environment have different influences on the susceptibility of the environment to low rainfall and hence to investment risk. Tilling the land exposes it to physical degradation. On the other hand, people involved in growing crops may be adding fertiliser, manure or mulch, removing weeds and alien species, increasing soil fertility through crop rotation, inter-cropping or using other practices that ameliorate rather than exacerbate the effects of little rain.

Mechanical ploughing is increasingly being used in rural communal areas in Namibia. This method requires less physical exertion than traditional ploughing methods, but has several negative implications for land management. Because of the high costs associated with purchasing and owning a tractor, one tractor is frequently shared by a number of families, or provided by the government to a number of areas. As a result the tractor is often not available for ploughing at the optimal time. This obviously influences the potential productivity of the crops, as well as the ability of the soil to withstand low or variable rainfall. Mechanical ploughing also allows large areas to be ploughed with relatively little effort. Often large ploughed areas are not planted in the season in which the soil has been prepared resulting in reduced soil resources through oxidation and loss of organic content, drying of the soil and erosion (C. Hines, pers. comm.). For ease of mechanical ploughing, fruit trees and other valuable perennial vegetation must be removed, reducing the human carrying capacity of the land even further (Marsh & Seely, 1992).

As populations increase, more people need land for fields, the fallow period shortens and the soil nutrients, fertility and productivity decrease. With a lower organic content in the soil, it dries out more rapidly, and consequently crops no longer survive what

previously was a tolerable period of naturally dry conditions. For example, in the Okavango region of Namibia the demand for land along the Okavango River has led to shorter fallowing periods and, as little soil fertilisation is practised, harvests are decreasing (Yaron *et al.* 1993). Areas where fertilisation is practised can also experience problems involving cost and availability of fertilisers, as well as salinisation, pollution of groundwater and runoff, and other symptoms of over-fertilisation.

Poverty, population pressure, available information, level of education and technology and a number of other factors will influence whether a particular group, involved in a type of activity, will increase or decrease the potential of an area for desertification. In a similar manner, rural people involved in livestock rather than, or in addition to, cropping will have a different set of influences on the environment (Tapscott, 1990) and its susceptibility to desertification.

Throughout Africa, the commercialisation of agriculture and the effects of human mismanagement have been implicated as two major factors exacerbating the effects of drought and leading to desertification (ODI, 1987). Donor-funded irrigation projects, officially-sponsored afforestation, major range projects and major soil and water conservation projects have more frequently contributed to desertification and exacerbated the negative effects of droughts than they have ameliorated these effects.

Manifestations of desertification in Namibia

Desertification resulting from the described proximate causes manifests itself in four primary ways in Namibia. These include:

- 1) reduction in vegetation cover and subsequent soil denudation follo-

- wing overgrazing,
 2) bush encroachment,
 3) deforestation,
 4) impoverished soil base resulting from over tilling.

Reduction in vegetation cover and subsequent soil denudation following overgrazing

Duration of grazing in dry areas is primarily influenced by provision of water supply. Prior to the introduction of artificial water points, a natural system of nomadism, dependent on rainfall that is variable in time and space, was followed by wild animals and later domestic stock. There is an extensive literature that suggests that African grasslands have adapted to survive under such grazing regimes (e.g. Savory, 1988; Trlica & Rittenhouse, 1993). With the introduction of artificial water points, game and stock can be kept in a locality for long periods.

Too many animals in one place for too long a period reduces the vegetation cover. Perennial grasses may be replaced by annual grasses, palatable species by unpalatable ones, and alien or native weeds may invade. While perennial grasses can respond to small amounts of rainfall, annual grasses require a higher minimum for germination. Given the low and variable rainfall in Namibia, it is common for large parts of Namibia to have minimal germination. Under these conditions, if perennial grasses have been eliminated, no fodder is available for livestock. At the same time, soil loss is enhanced as soil exposed by trampling and reduction of perennial grass cover is more susceptible to wind and water erosion and to desiccation and oxidation. Persistent overtrampling and wind erosion will lead to the reduction and ultimate eradication of seed banks that sustain grasslands.

How the processes of grassland deterioration take place appears to vary from region to region (Bosch & Theunissen, 1992) and is not well understood. Moreover, the time scale of recovery from over use is extended in arid and semi-arid lands because of low and variable rainfall. Examples in Namibia of what appear to be results of these or similar processes accompanying overgrazing can be found in all regions, in particular, Erongo, Kunene and Oshana.

Bush encroachment due to overgrazing

Bush encroachment is a common manifestation of inappropriate grazing management in semi-arid Namibia. Increased pressure on the grasses and small plants caused by grazing domestic livestock, coupled with decreased browsing of trees and shrubs, leads to bush encroachment. Change in the vegetation is thought to be accompanied by a change in the nutrient status of the soil (Schlesinger *et al.* 1990) so that reversal of bush encroachment is very difficult and expensive. Absence of burning may also be involved, and burning may be a tool to appropriately manage areas prone to bush encroachment. Mixed farming with browsing wildlife and grazing domestic livestock is another tool that may help reduce the susceptibility of the environment to drought and desertification.

Deforestation

Traditional timber-intensive agricultural activities, especially those occurring in northern Namibia, have resulted in the severe and ongoing deforestation of large areas (Erkkila & Siiskonen, 1992). The reduction of tree cover has far reaching environmental and economic consequences. Understorey microclimates are modified unfavourably for human and livestock comfort as well as for understorey production. On a much larger scale, deforestation can influence climate

through changed wind regimes but it is doubtful whether existing levels of deforestation in Namibia would have any measurable effects in this regard. Reduction in tree cover negatively influences soil fertility, especially when the abundance of nitrogen fixing species declines. Reduction in tree cover exposes the ground to higher wind speeds and temperatures thus exacerbating the soil erosion potential and desiccation of the soil and vegetation, including crops, that it supports. Reduction in tree cover exposes the soil to increased water erosion owing to less protection from rainfall energy.

Throughout Namibia, as in much of Africa, use of wood for fuel has reduced woody shrub and tree cover. Pressure from domestic stock prevents establishment of elements of the woody vegetation, particularly along dry water courses (EEAN, 1992a).

Impoverished land resulting from over tilling

Over tilling may reduce productivity of the land through a variety of mechanisms (Masdar, 1993) and consequently increase the susceptibility of the environment, and the people dependent on it, to drought and desertification. Over tilling can contribute to desiccation, wind erosion, water erosion, oxidation of organic matter, physical disturbance of the soil structure and invasion by alien vegetation.

RECOMMENDATION FOR ACTION

What direction will the renewed interest and study of the broad subject of desertification, as called for by the African nations at the Earth Summit, take? Having studied the desertification literature to date, and viewed the processes and causes in Namibia, we are

well aware of the complications confronting us as we reach for solutions to the problems of desertification. This is a human problem (Darkoh, 1993). Numerous human activities are known to increase the susceptibility of the land to drought and desertification. Some of these are derived from and based upon adaptive strategies that have been serving people for millennia. Others have evolved in the recent past, but are still considered part of the traditional agricultural practices, such as the cultivation of maize, or farming with livestock. The problems that face us today however, are largely the result of the application of inappropriate technologies for arid systems or the over-use of the land as a result of population and economic pressures. Independent Namibia finds itself at a turning point in world history in which traditional land use management systems have been found to be inappropriate for the rapid changes occurring in population numbers, aspirations of society, education, and energy and technology availability. It is vital that we grasp the significance of these transformations so that we can anticipate, further change and develop appropriate, adaptive responses to it.

Any change that will reduce desertification susceptibility in Namibia will have to be acceptable to those people currently making their livelihoods through maladaptive activities. Traditional land use practices and natural adaptive strategies which promote long-term sustainable use of natural resources must be reinforced. A proactive approach to our semi-arid and arid environment must at the very least involve the development of a national drought coping strategy fully integrated into Namibia's national development plans.

Awareness, education and training form the basis upon which a reduction of desertification potential and mainte-

nance, or adoption, of sustainable land use practices will be established. For example, much of the information available in Namibia about drought is not entirely appropriate. Urban populations (providing donor and government support for rural water needs) generally view drought as abnormal or unusual, and not something for which people can plan or prepare. In addition, droughts are viewed as something caused by the environment over which people have little control. The view of drought expounded herein, as the natural condition of a country with little and variable rainfall, must be vigorously promoted, before people will understand that the effects that drought has on their lifestyle is largely determined by their dependence on and use of a scarce commodity: rainfall.

To improve awareness, education and training, there needs to be an improved knowledge base and increased understanding of all the factors surrounding Namibia's natural resources. An understanding of the interface between human activities and the environment is particularly important. Monitoring and evaluation of human activities impinging on susceptibility to drought must be established and maintained as basic research programmes. Such monitoring and evaluation must be thoroughly integrated into awareness, education and training and based upon knowledge and understanding of processes contributing to and exacerbating effects of low and variable rainfall. Research activities in Namibia should address socio-economic, agricultural, political and educational aspects of desertification in addition to the bio-physical aspects.

Research at the Desert Ecological Research Unit is currently focusing on numerous issues relating to desertification and natural resource management. For example, conflicting water needs resulting from over-utilization of

ephemeral rivers in western Namibia are being addressed in a study investigating the importance of seasonal water flow to the downstream reaches of these rivers. In general, research, education, training and awareness of all citizens must be more fully integrated and receive greater attention if long-term solutions for reduction of maladaptive land use activities that exacerbate effects of natural drought in Namibia are to be achieved.

Droughts are constantly present in arid countries. To maintain awareness of their likelihood in Namibia, to assist with their study and to help plan for drought, a documentation centre pertaining to human activities and the environment is essential. This is particularly important because of the major input into activities exacerbating and/or ameliorating drought carried out by persons and organisations not intimately familiar with the Namibian environment. Many of the drought 'disasters' elsewhere in Africa are partly, if not entirely, the result of misdirected aid that was based upon knowledge and understanding from less arid areas of the world. Negative over-reaction to drought can, and usually does, increase susceptibility to subsequent droughts. Namibia needs to develop its own institutional memory of the environment and of less dry and more dry times as they naturally occur. At the Desert Ecological Research Unit, knowledge gained from 30 years of environmental study in Namibia is currently being integrated onto cross-curricular educational materials being prepared by the Enviroteach programme on water issues, energy, population and natural resource management for the secondary school level (du Toit *et al.* 1992, 1993, in press, in prep.). Various environmental awareness documents aimed at decision makers, from individual farmers to extension workers to government ministry officials and aid agencies have been or are being prepared by staff at the Research Unit

(e.g. Jacobson & Seely, in prep.; Marsh & Seely, 1992; Seely, 1991).

As bio-physical scientists, we alone can not solve the problems surrounding desertification. Having identified the problems, as scientists, we must now as citizens, convince our politicians that issues of land tenure and water rights should form candidacy platforms and are essential issues requiring legislation. Somehow we must convince journalists that conferences covering these subjects are important news items, the consequences of which will be felt by Namibian citizens in less than 10 years and for centuries to come. And, as people with an understanding of the causes and processes of desertification, we must make sure our specialised knowledge is accessible for interpretation by textbook writers, extension workers and others who directly influence how our drylands are used. The challenge for bio-physical scientists now is adopting and becoming involved in a multi-sectorial, multi-disciplinarian approach to desertification. This is a tremendously important task that requires our best bio-physical minds to communicate with, as well as develop basic skills in, disciplines such as politics, economics, journalism and social science.

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