Land degradation in the Sahel-Sudan: the conceptual basis

Kjeld Rasmussen

Abstract

The concepts and terminology of desertification and land degradation are discussed with particular reference to the Sudan-Sahel zone of West Africa. It is argued that apparent disagreement and confusion concerning environmental change processes in the region have a number of sources. These include vagueness of the definitons of concepts, the discipline-specific use of terminology, lack of hard data with the required historical depth and disregard of spatial variability and spatial and temporal scale issues. Material from case studies on desertification and land cover change in northern Burkina Faso and on vegetation productivity in pastoral areas of northern Senegal are used to illustrate these points. Further, it is argued that land degradation and desertification are inherently normative concepts, and that differences in world views and interests will influence how environmental changes are interpreted. Finally, the institutionalization of the concepts of land degradation and desertification is briefly discussed.

Keywords

Land degradation, desertification, Sahel-Sudan, Burkina Faso, Senegal.

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Introduction and objectives

This paper will discuss the conceptual basis of the scientific debate on environmental change in the West-african Sahel-Sudan region, defined as the area between the 200 and 600 mm isohyets south of the Sahara. The concepts of 'desertification' and 'land degradation' have played a major role in this debate over the last two or three decades. It will be argued that several problems persist in the scientific understanding of environmental change in the region, and these will be traced to a number of sources, including:

(1) Vague definitions of the concepts of desertification and land degradation.
(2) Discipline-specific usage of concepts and terminology.
(3) Lack of hard data on the environmental histories of the regions studied.
(4) Neglect of spatial variability.
(5) Insufficient understanding of the time scales of environmental change processes.

Results from case studies in northern Burkina Faso and Senegal will be used to illustrate the difficulties associated with the use of the concepts of desertification and land degradation.

Weaknesses of the definition and use of concepts

A great number of definitions of 'desertification' have been suggested. Following the Rio-conference and the 'Convention to Combat Desertification' (UN, 1992), the most widely used is:

'Desertification is land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities'.

which is devoid of meaning without a proper definition of 'land degradation'. Again, many different definitions have been suggested. One of the most generally accepted is probably that of Williams & Balling (1995):

'Reduction of biological productivity of dryland ecosystems, including rangeland pastures and rainfed and irrigated croplands, as a result of an acceleration of certain natural processes'

Whenever the terminology of desertification and land degradation is used below without further specification, it will refer to these definitions. This implies that the terms are interchangeable. Though widely used, Williams & Ballings' definition of land degradation leaves many issues unresolved. Of particular importance is the issue of time scale, which will be addressed in this paper.

The broader - yet far from universal - acceptance of these definitions gives some hope of greater consistency in the scientific debate, yet they are still vague and open to numerous - and sometimes mutually exclusive - interpretations, causing considerable confusion. Most importantly, these terms are inherently normative. The practical definition of degradation tends to become *'any undesired change in vegetation, soils, landscapes etc'*. Since different people, scientists as well as others, have different preferences, the understanding of degradation will differ widely. This will be examplified below.

In the following discussion a number of problems, rooted in the normative character and the lack of precision in the definitions and the practical use of concepts, will be briefly discussed. Some of these problems are internal to science, some are linked to the translation of scientific understanding into policy. However, the emphasis in this paper will be on the aspects internal to science.

Discipline-specific use of terminology

One source of confusion concerning desertification and land degradation is the differences in the use of (land) degradation terminology between scientists and practitioners in different disciplines. One example - in relation to semi-arid rangelands - may be the discipline specific understanding of 'degradation' (and not specifically land degradation):

- Seen from a botanist's point of view, the term degradation may be used to describe a change in vegetation composition of a region, involving, for instance, the disappearance of characteristic tree species.

- In range management, 'range degradation' may denote that the appearance of the range differs from an ideal picture of how a well-managed rangeland looks. Scoones (1993) documents how assessments of carrying capacity in Zimbabwean rangelands depended upon the judgement of colonial range managers carrying with them notions from temperate regions.

- In geomorphology and soil science, an area will be described as undergoing 'degradation', if there is an increase, relative to some 'natural' level, of the loss of topsoil by erosion.

- In hydrology 'degradation' may be associated with a decrease in infiltration and increased surface run-off caused by surface crust formation.

- In forestry, reduction of the woody cover, of woody productivity and/or qualitative changes in species composition will be seen as 'degradation'.

- In economy, loss of economic productivity of the land will be the criteria for 'degradation'.

However, there is no certainty that any of these processes lead to reduced biological productivity (at some specified scale), as demanded by the above standard definition. Warren (1998) has pointed this out in relation to soil erosion. Thus, irrespective of the apparent concensus on the 'land degradation' terminology and definition, differences in the actual use of the broader term 'degradation' prevail. Even though these differences may be based on well-established traditions within each discipline, and each of them describes interesting and relevant environmental changes, the shared usage of the 'degradation' term causes confusion both within and outside science.

As mentioned, land degradation may encompass a variety of processes such as (1) impoverishment of the vegetation (including loss of biological diversity), (2) soil erosion by wind and water, (3) depletion of soil nutrients, (4) changes in the physical structure of the soil, including surface crusting, (6) salinization of irrigated areas, as well as others. These processes affect very different environments, have different causes, and their occurrences within a certain region are not necessarily positively correlated - or related at all. It is therefore highly questionable whether it is meaningful to merge these processes under one heading.

Exaggerated figures and lack of hard data

There is a stunning contrast between - on the one hand - the ambiguities of the concepts and the problems of measurement associated with them, and on the other, the apparent precision of some of the data presented by authoritative sources, e.g. Le Houérou (1996). Very detailed quantitative data are presented on extent, rates and even causes of desertification. The numbers presented on extents and rates are extremely large, yet little proof of their validity is offered. Olsson (1993), Warren (1998) and others provide a sharp critique of such aggregates, yet the numbers continue to be put forward. As will be discussed below in relation to case studies from northern Burkina Faso and Senegal, it is hard to imagine how such precise data could be produced.

Neglect of spatial variability and differences in scale

Sweeping generalisations about land degradation are sometimes made on the basis of case studies related to small areas without proper considerations of their representativity. The revitalisation of the fossil dunes in the vicinity of Oursi in northern Burkina Faso is a good example (Claude et al., 1991 ; Krings, 1980). While this is an interesting case, it is certainly not representative of the region, as will be described below.

Research in land degradation processes tends to be scale-specific: Work is carried out at plot- (Krogh, 1997), village- (Reenberg et al., 1998), landscape- (Rasmussen et al, submitted), regional (Krings, 1980), national or subcontinental (Tucker et al., 1991) scales, and conclusions reflect the scale of analysis. Few studies succeed in effectively integrating scales, and to maintain the precision, rigour and processual understanding obtainable at the finest levels, while at the same time assuring spatial representativity at larger scales of greater policy relevance. The hierarchical approach outlined by Reenberg (1998) may be one way to obtain this.

(Ir)reversibility, stability and resilience

Much confusion has arisen from controversies concerning the possible irreversibility of land degradation processes. One source of confusion relates to the - often implicit - assumption that some state of the ecosystem is the 'natural' (Sprugel, 1991) stable state, and that a disturbance, be it a drought or human intervention, would move the system away from this state. If the disturbance were large enough, and the system sufficiently vulnerable, the system would not be able to return to the equilibrium state, and the change would be termed irreversible. The validity of this idea of ecosystem behaviour has been questioned, and semi-arid areas may alternatively be described as 'event-driven' systems, constantly undergoing change (Ellis & Swift, 1988 ; Scoones, 1993 ; Behnke & Scoones, 1993). However true it may be that variability is an important feature of dryland ecosystems, it should be remembered that pollen analysis of sediment cores from lakes in the Sahel-Sudan shows a relatively constant floral composition over the last three thousand years (Andres et al., 1996). This indicates that whereas productivity and relative abundance of species may be characterized by variability, ecosystem structure and species composition may be relatively stable. However, much more research is required to resolve this question.

Case studies

The discussion below will draw upon two case studies - related to different presumed land degradation processes - from Burkina Faso and Senegal. Both will be presented very briefly, emphasizing the conclusions of direct relevance to the present discussion.

Vegetation change on the stabilised dunes of northern Burkina Faso

Rasmussen et al. (submitted) and Fog & Rasmussen (1997) have studied the environmental history over the last 40 years of the stabilised dunes of northern Burkina Faso. The study is based on analysis of time series of aerial photos and satellite images, in combination with field observations and interviews with local farmers and pastoralists.

The findings may be briefly summarized as follows:

(1) In the years of the drought of the early seventies the vegetation cover on the dunes changed significantly. In some cases these changes continued until the mid-eighties. Several woody species were almost irradicated (Rasmussen et al., submitted), the herbaceous cover was reduced substantially in certain areas (and not in others), and annual grasses replaced perennials. Certain parts of the dunes became totally denuded, and wind erosion became prominent, revitalising the otherwise stabilised dunes.

(2) Since the late eighties - and in some cases earlier - the vegetation cover has been recovering. The species invading the denuded parts of the dunes are not identical to those dominating before the drought. Among the woody species, *Leptadenia pyrotechnica*, which is well-adapted to desert-like conditions, has often been the first to appear. The reduction of the area of bare spots on the dunes is clearly visible from both aerial photos and satellite images, and the interviews with local people support this conclusion.

(3) Large differences between the vegetation histories between different parts of the dunes - even within the small area studied - have been observed. These differences are likely to be due to a combination of natural and human causes. The areas of total denudation in the seventies are all close to settlements and/or temporary ponds with periodically high livestock grazing pressure and trampling. Cultivation on the dunes was widespread up until the early seventies and sometimes, yet not always, caused revitalisation of the dunes by wind erosion.

One specific example is shown in Figure 1. The changes in vegetation cover on the 'Oursi-dune', which have been the subject of several studies (Claude et al., 1991 ; Lindquist & Tengberg, 1993 ; Toutain & De Wispelaere 1977), are visible by comparison between geometrically co-registered and radiometrically normalized aerial photos from the period 1955 to 1994 (Rasmussen et al., submitted).

The case illustrates well a number of points, discussed above. Areas supposedly undergoing land degradation (Lindquist & Tengberg, 1993) are actually rapidly recovering, even though the overall utilization pressure is hardly reduced. This may be said to support the idea of the herbaceous vegetation cover and productivity being more directly controlled by rainfall, rather than by human-induced land degradation processes. It should be added, however, that the recovery does not necessarily lead to reestablishment of the pre-1970 situation. The species currently invading the live dunes - created in the seventies - are not the same as those dominating before. The dunes display a pattern including both 'irreversible' and 'reversible' changes with varying time scales. This will be elaborated upon below. Further, the observed spatial variability points to the necessity of caution when extrapolating from local scale findings. Finally, it should be added that other parts of the same area (plateaus and valleys) with a different

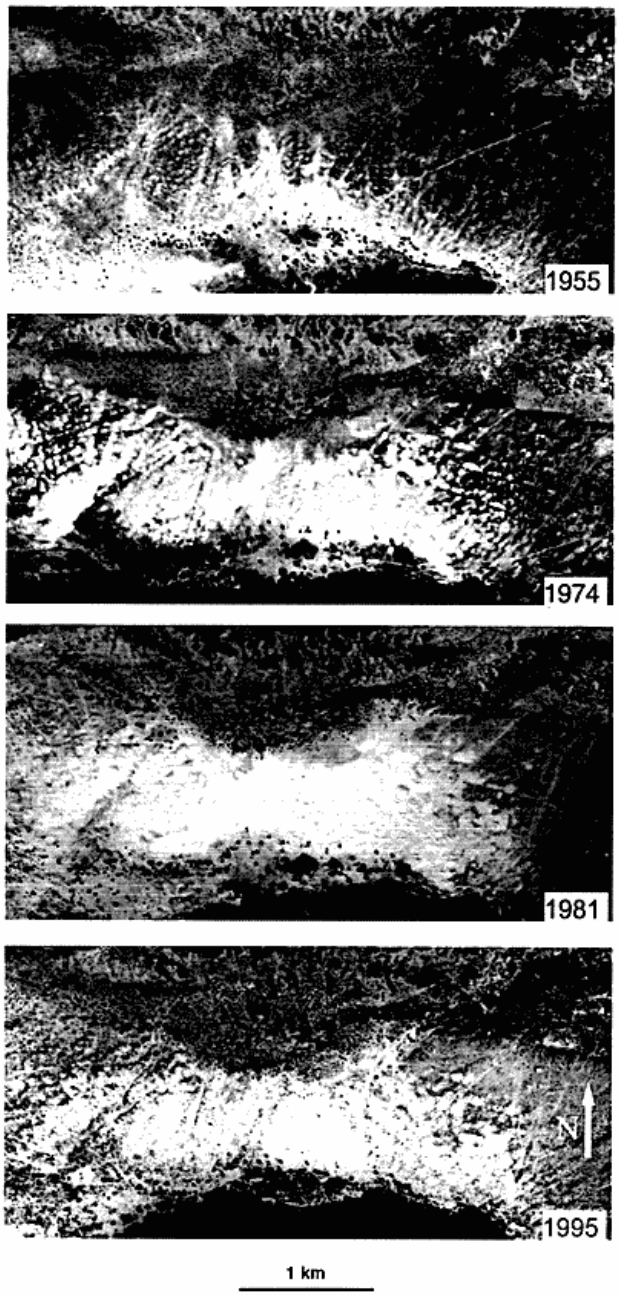

Figure 1: *Aerial photos showing the change in land cover on the Oursi dune between 1955 and 1995. The photos have been scanned, geometrically corrected and radiometrically normalized in order to allow direct comparison. The 'Mare d'Oursi' can be seen in the bottom of the photos, and the village of Oursi is situated between the bright dune and the 'mare'. The invasion of bushes and herbs between 1981 and 1995 is clearly visible.*

geomorphology and utilization history are undergoing quite different change processes.

Land degradation around watering points in northern Senegal

Watering points for livestock in semi-arid rangelands are often assumed to be foci of land degradation. Many years of high grazing pressure may create so-called piosphere patterns (Bastin et al. 1993), and net primary productivity (NPP) may be suppressed in the long term. Few empirical tests of this idea have been carried out in the Sahel-Sudan. Hanan et al. (1991) used time-series of NOAA AVHRR satellite data to assess the variation of NPP with distance along radial profiles from watering points in the Ferlo of northern Senegal. The conclusion was that no clear indications of 'grazing gradients', as the phenomenon is termed, were identified. Recently, Rasmussen et al. (1999) have studied the issue in more detail for eight watering points in two different years, using a slightly different method, and the results were less clear. Grazing gradients were found in some cases and not in others.

In brief, the method is as follows: The NPP is estimated for each 1 km^2 'pixel' by integrating, over the growing season, the 'normalized difference vegetation index' (NDVI) calculated from daily NOAA AVHRR data. The 'integrated NDVI' (iNDVI) has been shown to be linearly related to NPP by Rasmussen (1998) for the area in question. Subsequently, the average iNDVI for all pixels at a certain distance from the watering point has been plotted against distance. The method differs from that of Hanan et al. (1991) by using all pixels for studying the iNDVI-distance relation, not only those on a certain radial profile.

In Figure 2 (next page) the iNDVI-distance relation is shown for eight watering points in north-west Ferlo for 1989, which was an unusually wet year. 'Normal' grazing gradients, i.e. reduced NPP close to the watering points, are found for several - but not all - watering points. Certain watering points, e.g. Thiel, display an 'inverse' grazing gradient, as also observed elsewhere (Bastin et al., 1993). Several explanations of this phenomenon may be suggested. In Thiel, field work has demonstrated that the presence of unpalatable species of high productivity and greenness in the proximity of the watering point may constitute part of the explanation. One such species, *Casia obtifolia*, which is adapted to areas with high nitrogen and phosphorous availability due to manure, is quite widespread around watering points in the southern part of the Ferlo. The dominance of such species may be seen as an effect of high grazing pressure over a prolonged period. Another explanation of the inverse grazing gradient may be that certain watering points, including Thiel, are closed during the rainy season, since water is available from temporary ponds. If the development of a grazing gradient depends on the grazing pressure in the rainy season, as suggested by Turner (1998), areas close to the watering point, which are used less in the rainy season, will be less affected.

The applied method is based on several assumptions, the most important being that the NDVI must not be seriously affected by grazing in the current rainy season. This condition may not hold in dry years close to watering points.

The conclusions which may be drawn from this preliminary study of grazing gradients are the following:

(1) 'Normal' grazing gradients, indicating that NPP has been suppressed by grazing pressure, do occur in the study region.
(2) Cases of 'inverse' grazing gradients are found as well, indicating that NPP is increased rather than decreased around the watering point. However, field observations indicate that such gradients are in some, but not all, cases related to the presence of unpalatable species, and thus the economic and nutritional value of the vegetation may be reduced.
(3) Substantial local variations (and variations between years) occur, some related to natural phenomena, e.g. the presence of temporary ponds, causing a more spatially even distribution of grazing pressure, some probably related to natural resource management practices.

In relation to the above discussion of land degradation, the case study findings imply that the simple definition of land degradation, relating it to the NPP (and to NDVI determined from satellite images), does not take into account the 'value' of the vegetation seen from a production point of view. The same may be said about other 'value' aspects of vegetation. Further it implies that generalisations - even for a relatively homogeneous area like western Ferlo - concerning land degradation are risky due to great spatial variation in the observed patterns.

Time scales of environmental change

The definitions of desertification and land degradation do

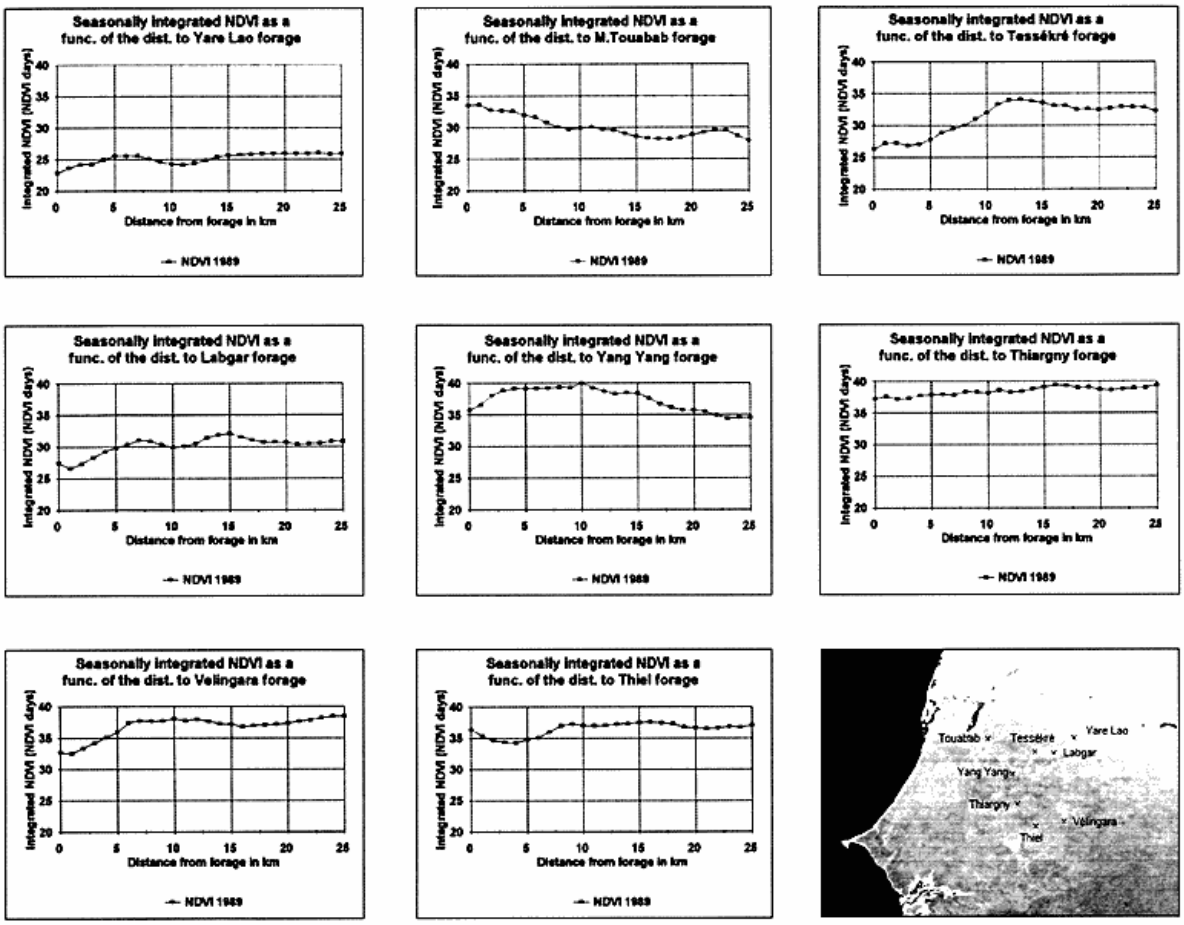

Figure 2: The variation of iNDVI, which is assumed to be linearly related to NPP, with distance from the boreholes ('forages') in the Ferlo of northern Senegal. Increasing iNDVI with distance is termed a 'normal' grazing gradient; decreasing iNDVI with distance an 'inverse' grazing gradient. The iNDVI is obtained by integrating over the period June to October the 'normalized difference vegetation index', computed from calibrated NOAA AVHRR satellite images. From Rasmussen et al. (1999).

not specify the time scales considered. No indications of how long an environmental change must persist in order to be termed 'land degradation' are given. The different processes of environmental change, represented in the case studies introduced above, operate at very different time scales. Attempts to assess the extent of land degradation from empirical evidence of changes, taking place over few - or few tens of - years, may be hazardeous, since the observed changes are likely to be the combined result of several processes operating on different time scales. At one extreme, vegetation productivity may fluctuate widely from year to year, while, at the other extreme, large-scale ecosystem shifts caused by climate change may have time scales of hundreds or thousands of years. In between these extremes, human effects on ecosystems may be observed with time scales of decades (Toutain & De Wispelaere, 1977), and soil erosion processes may be studied at time scales of decades to centuries (Warren, 1998).

Since long-term environmental information is scarce, much thinking tends to be based on deductions from the observation of present conditions, as discussed by Fairhead (1998) with reference to a more humid zone, or on short time-series of data. Satellite images or aerial photos covering few decades and interviews with informants who

necessarily have a limited precision of memory (and probably sometimes a systematically distorted view) of the environmental history, are some of the sources used. This has the effect that high current change rates will tend to dominate the picture, as compared to processes with longer time scales and lower annual change rates. The processes with longer time scales will possibly have larger long-term effects, however.

Normative, social and perceptional aspects of land degradation

Most natural scientists studying land degradation tend to regard it as the result of measurable physical, chemical and biological processes. However, the whole concept is basically of a normative nature. As stated above, land degradation may be said to have the practical definition, *'any undesired change in vegetation, soils, landscapes etc'*. If this statement is accepted it implies that land degradation is a strongly (negatively loaded), normative concept, which may be said to be unfortunate in a scientific context. The normative character of the concept leads to the conclusion that differences in world views, priorities and interests may influence what is termed land degradation. Such differences exist even between scientists, as illustrated above, and even more so in a wider context, as discussed by Swift (1996).

As part of the study of vegetation change in the northern part of Burkina Faso, briefly described above, local people were interviewed on their perception of environmental change in the region. It was clear that perceptions of land degradation expressed by local farmers and pastoralists differed from those of scientists and development workers. Whereas well-educated technicians and administrators univocally supported the 'narrative' of land degradation, the farmers acknowledged that environmental changes were taking place, but not that these changes always represented 'problems'. For example, depletion of woody resources, fuel wood shortage and soil nutrient depletion, which are often described as serious in the land degradation debate, are not generally considered important problems. Further, the view of local people was that environmental change is caused by drought and not 'human mismanagement', in contrast to what is suggested by, for instance, Le Houérou (1996). Such discrepancies cannot just be written off as a consequence of a lack of understanding on the part of the farmers. They may be seen as a consequence of differences in priorities and interests.

The relatively recent 'Convention to Combat Desertification' actually differs from earlier official texts by emphasizing the need to take local perceptions of land degradation into account and to involve local populations in the process of prioritizing the actions to be taken to improve environmental conditions.

Institutionalization of desertification

Not least in a UN context, desertification has become an official and political concept, as much as a term describing certain well-defined physical, chemical and biological processes. Institutions are built around it, both within the UN system (e.g. UNSO) and at national level. Third World countries are required to deal with the concept due to the external demand to develop and implement various environmental action plans. Government officials and scientists in these countries have responded quickly by adopting the vocabulary of the UN-literature, and local institutions are involved in carrying out studies and formulating action plans, thereby getting access to funds. Often representatives of developing countries defend the traditional interpretations of desertification in UN contexts. One may fear that the environmental policies arising from this perception - if they have an effect at all - do not always focus on the environmental problems of greatest concern to the major part of the population, but rather reflect the, not necessarily empirically based, ideas of the institutions, international as well as national, which build upon the desertification concept.

Critical assessment - based on empirical evidence - of environmental change processes, their relation to production systems and natural factors, the costs and benefits associated with them, the local perceptions of them, as well as the policies required to manage them, is required. Such critical empirical assessments should be a prerequisite for the development of national action plans, environmental policies and development projects within natural resource management.

Conclusions

The main messages which may be extracted from the above discussion are the following:

(1) The terminology of desertification and land degradation is, in spite of a possible emerging concensus on definitions, still vague. Very different practical interpretations, often specific to scientific disciplines, exist, which may give rise to confusion.
(2) The empirical basis for the current official assessments of the extent and causes of desertification remains weak, and can hardly serve as a good basis for environmental policies and practical action.
(3) Whereas micro-scale case studies are likely to provide examples of a wide range of environmental change processes which may be termed desertification or land degradation using the standard definitions, proper upscaling to national or regional scales of these results is seldom done. Instead sweeping generalisations are made directly on the basis of observations at micro-scale, and the validity of these generalisations is seldom empirically tested.
(4) Time-scales of environmental change processes differ widely. The lack of historical environmental data means that present day conditions and short time-series are used as a basis for assessing the relative importance of change processes. This may lead to false conclusions, because processes with short time-constants yet high annual change-rates tend to dominate, even though their long-term effects are limited.
(5) The concepts are inherently normative, and differences of perceptions and interests will influence what is considered 'degradation'. In particular, the views and interests of the rural population directly affected by environmental change may differ widely from those of researchers and the formally trained personnel of governmental institutions and development projects.

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References

Andres, W., Ballouche, A. & Müller-Haude, P. (1996): Contribution des Sédiments de la Mare d'Oursi à la connaissance de l'évolution paléo-écologique du Sahel du Burkina Faso. In: Berichte des Sonderforschungs-bereichs 268: 'Kulturentwiklung und Sprachgeschichte im Naturraum Westafrikanische Savanne. Frankfurt am Main.

Bastin, G.N., Pickup, G., Chewing, V.H. & Pearce, C. (1993): Land degradation assessment in central Australia using a grazing gradient method. Rangeland Journal 15 (2): 190-216.

Behnke, R.H. & Scoones, I. (1993): Rethinking range ecology: Implications for rangeland management in Africa. Pp. 1-30 in: Behnke, R.H., Scoones, I. & Kerven, C. (eds.): Range ecology at disequilibrium - New models of natural variability and pastoral adaptation in African savannas. London: Overseas Development Institute & IIED.

Behnke, R.H., Scoones, I. & Kerven, C. (eds.) (1993): Range ecology at disequilibrium - New models of natural variability and pastoral adaptation in African savannas. London: Overseas Development Institute & IIED.

Claude, J., Grouzis, M. & Milleville, P. (1991): Un Espace Sahélien. La Mare d'Oursi (Burkina Faso)(1976-1981). Paris., ORSTOM.

Ellis, J. & Swift, D.M. (1988): Stability of African pastoral ecosystems: Alternate paradigms and implications for development. Journal of Rangeland Management 41: 450-459.

Fairhead, J. (1998): Reframing deforestation: Escaping orthodoxies concerning deforestation in West Africa. Pp. 13-28 in: Reenberg, A., Nielsen, I. & Marcussen, H.S. (eds.): The Sahel: Sahelian perspectives - Myths and realities. SEREIN Occasional Papers 6. Copenhagen.

Fairhead, J. & Leach, M. (1996): Misreading the African landscape: Society and ecology in West Africa. London: Routledge.

Fairhead, J. & Leach, M. (1998): Reframing forest history: power, policy and ecology in West Africa. London, Routledge.

Fog, B. & Rasmussen, K. (1997): Detection of short term changes in the vegetation cover on a longitudinal dune in Oudalan Province, Burkina Faso. SEREIN Working Paper 27, Copenhagen.

Hanan, N.P., Prevost, Y., Diouf, A. and Diallo, O. (1991): Assessment of desertification around deep wells in the Sahel using satellite imagery. Journal of Applied Ecology 28: 173-186.

Krings, T.F. (1980): Kulturgeographischer Wandel in der Kontaktzone von Nomaden und Bauern im Sahel von Obervolta. Hamburger Geographischen Studien, Heft 36.

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References

Andres, W., Ballouche, A. & Müller-Haude, P. (1996): Contribution des Sédiments de la Mare d'Oursi à la connaissance de l'évolution paléo-écologique du Sahel du Burkina Faso. In: Berichte des Sonderforschungs-bereichs 268: 'Kulturentwiklung und Sprachgeschichte im Naturraum Westafrikanische Savanne. Frankfurt am Main.

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Claude, J., Grouzis, M. & Milleville, P. (1991): Un Espace Sahélien. La Mare d'Oursi (Burkina Faso)(1976-1981). Paris., ORSTOM.

Ellis, J. & Swift, D.M. (1988): Stability of African pastoral ecosystems: Alternate paradigms and implications for development. Journal of Rangeland Management 41: 450-459.

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Krogh, L. (1997) : Field and village nutrient balances in northern

Burkina Faso: A village case study. Journal of Arid Environments 35:147-159.

Le Houérou, H.N. (1996): Climate change, drought and desertification. Journal of Arid Environments 34: 133-185

Lindquist, S. & Tengberg, A. (1993): New evidence of desertification from case studies in northern Burkina Faso. Geografiska Annaler 75 (A 3): 127-135.

Olsson, L. (1993): Desertification in Africa - A critique and an alternative approach. GeoJournal 31(1): 23-31.

Rasmussen, K., Madsen, J. & Fog, B. (submitted): Desertification in reverse? Observations from northern Burkina Faso. Global Environmental Change.

Rasmussen, M.S. (1998): Developing simple, operational, consistent NDVI - Vegetation models by applying environmental and climatic information. Part I. Assessment of net primary Production. International Journal of Remote Sensing 19: 97-117.

Rasmussen, K., Ka, A., Fensholt, R. & Adriansen, H. (1999): Grazing gradients around deep boreholes in the Ferlo of Senegal. Proceedings VI Int. Rangeland Congress, Townsville, Australia July 1999: 769-770.

Reenberg, A. (1998): Analytical approaches to agricultural land use systems in the Sahel. SEREIN Occ. Papers 18, Copenhagen.

Reenberg, A., Louring-Nielsen, T. & Rasmussen, K. (1998): Field expansions and reallocations in a desert margin region - Land use pattern dynamics in a fluctuating biophysical and socio-economic environment. Global Environmental Change 8 (4): 309-327.

Scoones, I. (1993): Why are there so many animals? Cattle population dynamics in the communal areas of Zimbabwe. Pp. 62-76 in Behnke et al. (eds.): Range ecology at disequilibrium, London: ODI & IIED.

Sprugel, D.G. (1991): Disturbance, equilibrium and environmental variability: What is 'natural' in a changing environment? Biol. Conserv. 58: 1-18.

Swift, J. 1996: Desertification - Narratives, winners and losers. Pp. 62-76 in: Leach, M. & Mearns, R. (eds.): The lie of the land. The International African Institute. Heinemann & James Currey.

Toutain, B. & De Wispelaere, G. (1977): Pâturage de l'O.R.D. du Sahel et de la zone de delestage au nord-est de Fada N'Gourma (Haute Volta). Tome II. Les Plantes: Ecologie, noms vernaculaires, intérêt fourrager. I.E.M.V.T., Maisons Alfort, France.

Tucker, C.J., Dregne, H.E. & Newcomb, W.W. (1991): Expansion and contraction of the Sahara Desert 1980 to 1990. Science 253: 299-301.

Turner, M.D. (1998): The interaction of grazing history with rainfall and its influence on the annual rangeland dynamics in the Sahel. Pp. 237-261 in Zimmerer, K.S. & Young, K.R. (eds.): Nature's geography. University of Wisconsin Press.

UN (1992): Agenda 21: The United Nations plan of action from Rio. New York, United Nations.

Warren, A. (1998): Land degradation in the Sahel: Some observations. Pp. 1-12 in Reenberg, A., Nielsen, I. & Marcussen, H.S.(eds.): The Sahel: Sahelian perspectives - Myths and realities. SEREIN Occasional Papers 6. Institute of Geography, University of Copenhagen, Denmark.

Williams, M.A.J. & Balling, R.R.Jr. (1995): Desertification and climatic change. London, Edward Arnold.

(1) The terminology of desertification and land degradation is, in spite of a possible emerging concensus on definitions, still vague. Very different practical interpretations, often specific to scientific disciplines, exist, which may give rise to confusion.
(2) The empirical basis for the current official assessments of the extent and causes of desertification remains weak, and can hardly serve as a good basis for environmental policies and practical action.
(3) Whereas micro-scale case studies are likely to provide examples of a wide range of environmental change processes which may be termed desertification or land degradation using the standard definitions, proper upscaling to national or regional scales of these results is seldom done. Instead sweeping generalisations are made directly on the basis of observations at micro-scale, and the validity of these generalisations is seldom empirically tested.
(4) Time-scales of environmental change processes differ widely. The lack of historical environmental data means that present day conditions and short time-series are used as a basis for assessing the relative importance of change processes. This may lead to false conclusions, because processes with short time-constants yet high annual change-rates tend to dominate, even though their long-term effects are limited.
(5) The concepts are inherently normative, and differences of perceptions and interests will influence what is considered 'degradation'. In particular, the views and interests of the rural population directly affected by environmental change may differ widely from those of researchers and the formally trained personnel of governmental institutions and development projects.

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References

Andres, W., Ballouche, A. & Müller-Haude, P. (1996): Contribution des Sédiments de la Mare d'Oursi à la connaissance de l'évolution paléo-écologique du Sahel du Burkina Faso. In: Berichte des Sonderforschungs-bereichs 268: 'Kulturentwiklung und Sprachgeschichte im Naturraum Westafrikanische Savanne. Frankfurt am Main.

Bastin, G.N., Pickup, G., Chewing, V.H. & Pearce, C. (1993): Land degradation assessment in central Australia using a grazing gradient method. Rangeland Journal 15 (2): 190-216.

Behnke, R.H. & Scoones, I. (1993): Rethinking range ecology: Implications for rangeland management in Africa. Pp. 1-30 in: Behnke, R.H., Scoones, I. & Kerven, C. (eds.): Range ecology at disequilibrium - New models of natural variability and pastoral adaptation in African savannas. London: Overseas Development Institute & IIED.

Behnke, R.H., Scoones, I. & Kerven, C. (eds.) (1993): Range ecology at disequilibrium - New models of natural variability and pastoral adaptation in African savannas. London: Overseas Development Institute & IIED.

Claude, J., Grouzis, M. & Milleville, P. (1991): Un Espace Sahélien. La Mare d'Oursi (Burkina Faso)(1976-1981). Paris., ORSTOM.

Ellis, J. & Swift, D.M. (1988): Stability of African pastoral ecosystems: Alternate paradigms and implications for development. Journal of Rangeland Management 41: 450-459.

Fairhead, J. (1998): Reframing deforestation: Escaping orthodoxies concerning deforestation in West Africa. Pp. 13-28 in: Reenberg, A., Nielsen, I. & Marcussen, H.S. (eds.): The Sahel: Sahelian perspectives - Myths and realities. SEREIN Occasional Papers 6. Copenhagen.

Fairhead, J. & Leach, M. (1996): Misreading the African landscape: Society and ecology in West Africa. London: Routledge.

Fairhead, J. & Leach, M. (1998): Reframing forest history: power, policy and ecology in West Africa. London, Routledge.

Fog, B. & Rasmussen, K. (1997): Detection of short term changes in the vegetation cover on a longitudinal dune in Oudalan Province, Burkina Faso. SEREIN Working Paper 27, Copenhagen.

Hanan, N.P., Prevost, Y., Diouf, A. and Diallo, O. (1991): Assessment of desertification around deep wells in the Sahel using satellite imagery. Journal of Applied Ecology 28: 173-186.

Krings, T.F. (1980): Kulturgeographischer Wandel in der Kontaktzone von Nomaden und Bauern im Sahel von Obervolta. Hamburger Geographischen Studien, Heft 36.

Krogh, L. (1997) : Field and village nutrient balances in northern