LAND DEGRADATION MONITORING IN NAMIBIA: A FIRST APPROXIMATION

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Abstract. This paper presents development of a first approximation of a Namibian, national level, land degradation monitoring system. The process involved a large number of stakeholders and led to the definition of four primary indicators that were regarded as related to land degradation in Namibia: population pressure, livestock pressure, seasonal rainfall and erosion hazards. These indicators were calculated annually for the period 1971–1997. Annual land degradation risk maps were produced for the same period by combining the indicators. A time series analysis of results generated by indicators was undertaken at two sites. The analysis revealed a general trend towards an increased land degradation risk over the period 1971–1997. A decrease in annual rainfall and an increase in livestock numbers caused this negative trend at one site, while decreased annual rainfall and increased human population were the causes at a second site. Evaluation of resulting maps through direct field observations and long-term monitoring at selected study sites with different conditions relevant for the indicators defined, is an essential next step.

Keywords: desertification, Geographic Information Systems, GIS, indicators, land degradation, Namibia.

1. Introduction

This paper presents a first approximation of a Namibian, national level, land degradation monitoring system, initiated by Namibia's Programme to Combat Desertification (Napcod), using four indicators to monitor the risk of land degradation in Namibia.

For this study, the United Nation's definition of desertification was used, i.e., land degradation in arid, semi-arid and sub-humid conditions, caused by various factors, including climatic variations and human activities (UNEP, 1999). Land degradation is a growing problem in drylands world-wide (Swift, 1996; UNEP, 1999; Van Rooyen, 1996). However, the debate on land degradation in the drylands of Africa is fraught with confusion and disagreement concerning magnitude, severity and causes of the observed changes (Agnew and Warren, 1996; Swift, 1996; Warren, 2002; Warren and Agnew, 1988). Major reasons are the uncertainties, inaccuracies and non-standardisation inherent in methodological tools and analytical models (Sullivan, 2000; Swift, 1996).

In Namibia, 70% of the population is dependent on subsistence farming (Kruger, 2001; Quan *et al.*, 1994b). The land tenure system is divided into two main categories, communal and commercial land. Communal tenure land is owned by the

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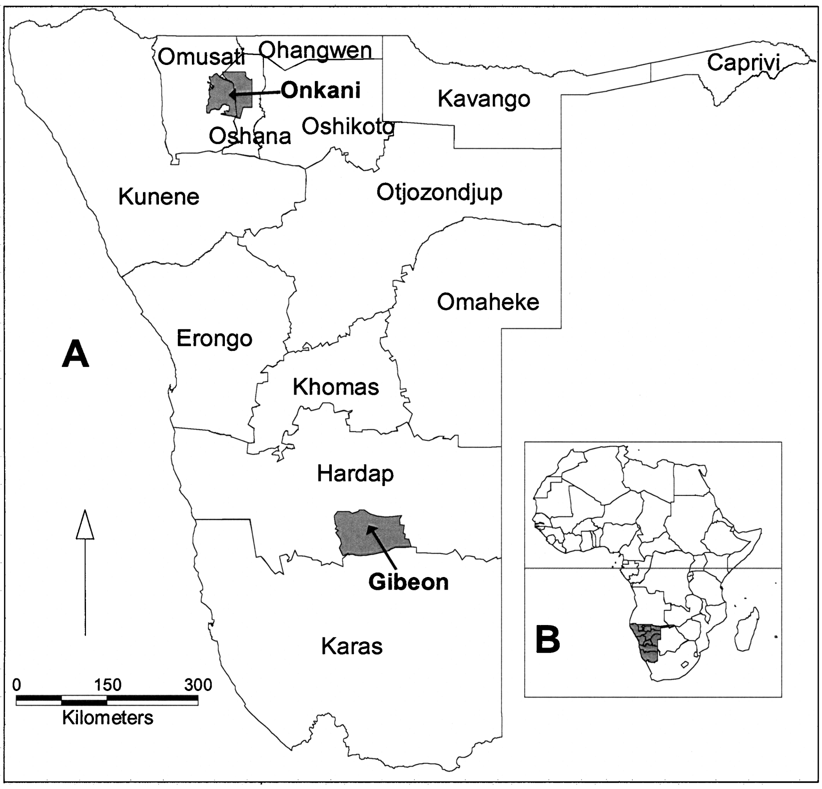

Figure 1. The 13 regions of Namibia and two Napcod pilot areas referred to in the text (Map A). Map B shows the location of Namibia on the African continent.

government and can be used by anyone, but with no exclusive rights. Commercial, freehold land is owned by individuals with exclusive rights. The population of 1.8 million is relatively small but growing rapidly at an annual rate of 3.1% (Central Bureau of Statistics, 1994). The population increase has led to higher pressure on the country's natural resources (Seely *et al.*, 1995). This is evident in communal tenure areas, where land degradation is a growing problem (Adams and Devitt, 1992; Quan *et al.*, 1994b; Seely *et al.*, 1995; Wolters, 1994). According to Seely and Jacobson (1994), proximate causes of land degradation in Namibia include both biophysical and land management factors. Non-adaptive management in a highly variable climate is seen as a major cause of land degradation (Naraa *et al.*, 1993; Van Warmelo, 1962). Seely and Jacobson (1994) state that reduction in vegetation cover and subsequent soil denudation following intensive grazing can be found in all regions but in particular, in the Erongo, Kunene and north-central regions (Figure 1). Sullivan has recently challenged these views on the basis of a study in Kunene, north-western Namibia, concluding that land degradation is not as widespread as commonly perceived (Sullivan, 1998; Sullivan, 2000). A recent project carried out in the same area, the Hoanib River Catchment Study, provided information that also contradicts the perception of land degradation as being a major problem (Leggett *et al.*, 2002). In contrast to the situation in north-western Namibia, land degradation is clearly a problem in north-central Namibia owing to deforestation and soil nutrient depletion (Erkkilä and Siiskonen, 1992; Quan *et al.*, 1994a).

Even though rainfall is one of the most important factors influencing environment in Namibia (Ward *et al.*, 1998), it is difficult to establish what influence climate has on the rate of land degradation. Highly variable rainfall between years is normal and has not been correlated to occurrence of land degradation (Tyson, 1986, 1991). Rainfall has a major influence on soil erosion (Morgan, 1991), but influence of human land uses is regarded as having an additive impact on rate of land degradation in Namibia. If human land uses have an impact on the rate of land degradation, it can be assumed that during a drought year, pressure on natural resources would be higher than during a 'normal' year, and would therefore increase the risk of land degradation.

At the start of this project, main causes and effects of land degradation in Namibia were discussed with representatives from local communities (three farmers' associations), government (four ministries), non-governmental organisations (two) and the private sector (three institutions). These representatives were consulted either in one-on-one sessions or at workshops. Additional information was gathered from literature. On the basis of findings from these consultations and the literature, it was agreed that land degradation in Namibia is caused by increased population density, leading to decreasing field sizes, over-consumption of wood for fire and construction, intense grazing due to overstocking and limited free movement of livestock. The most alarming effects of land degradation were confirmed to be deforestation, decreased availability of palatable grass species, soil erosion, bush encroachment and soil salinisation (Klintenberg *et al.*, 2001).

2. Combating Desertification in Namibia

Namibia signed the international Convention to Combat Desertification (CCD) in June 1994, (UN, 1994) and Napcod was launched in the same year. The programme addresses political, socio-economic as well as biophysical aspects related to land degradation (Napcod, 1999). Between 1994 and 1999, Napcod worked towards raising awareness about causes and effects of land degradation, both on national and local levels. Local-level activities were focussed at three communities. Involvement of Napcod led to increased awareness of land degradation and establishment of local-level monitoring systems at the selected communities, but had little impact on communities not directly involved.

Stakeholders on both national and local levels voiced a need for improved information about the location and rate of land degradation in Namibia. This led to development of a first approximation of a national indicator-based land degradation monitoring system. The process of establishing this national monitoring system in close co-operation with both local communities and scientists, and the resulting national land degradation risk maps are presented in this paper.

3. Developing a Land Degradation Monitoring System

A participatory approach was taken from the onset of this project, involving stakeholders on both national and local levels, throughout. Local communities were involved in the early stages, identifying land degradation issues and monitoring needs. Involved communities were continuously informed about the progress of the project. Stakeholders on national level have been part of the process, contributing to identification and definition of indicators. A technical working group was formed, where representatives from a number of departments within the Ministry of Agriculture, Water and Rural Development (MAWRD) and the Ministry of Environment and Tourism (MET) met regularly with the project team to discuss aspects of the monitoring system. The system was presented and discussed at two national workshops, where stakeholders from government and private sectors gave inputs.

Development of the first approximation of a Namibian national land degradation monitoring system followed three steps:

1. Identify and develop potential indicators for monitoring land degradation at national scale.
2. Gather required data sets.
3. Develop a Geographic Information Systems-based (GIS-based) system that can produce annual updates of the status of land degradation in Namibia.

3.1. Identify and develop potential indicators for monitoring land degradation at national scale

In 1992 the United Nation's Conference on Environment and Development (UNCED) approved Agenda 21 as an international action plan for sustainable development (CIESIN, 2001). Chapter 40 of Agenda 21 calls for improved environmental information as a pre-requisite for reporting on progress towards sustainability. This led to development of national state of environment reports, based on core sets of environmental indicators. Various indicator-based frameworks have been developed for monitoring environmental conditions, e.g., pressure, state and response framework, PSR (OECD, 1993) and driving forces, pressure, state, impact and response framework, DPSIR (CEROI, 2001). UNEP and UNDP/UNSO have jointly initiated a programme to develop desertification indicators in response to Agenda 21 (UN, 1993). They recommend that countries involved in combating desertification use indicator-based monitoring and GIS for development of policy and National Action Plans (NAPs) (UN, 1994).

In Namibia, the process of defining national environmental indicators was initiated in 1998, and has resulted in seven sectoral reports reflecting the state of environment (Klintenberg, 2001). Development of a core set of environmental indicators was based on the PSR framework as defined by OECD (OECD, 1993). The process of defining the land degradation indicators presented here followed a methodology suggested by several authors, similar to that applied in the establishment of the Namibian state of the environment indicators (Bossel, 1999; Meadows, 1998). In the absence of an accepted set of applicable land degradation indicators, potential indicators were suggested by stakeholders, based on main issues identified and confirmed, and combined with relevant indicators defined by the state of environment project (Klintenberg, 2001). These indicators were presented and discussed at a workshop, where participants ranked them according to their perceived relevance to monitoring of land degradation in Namibia.

The stakeholder consultations resulted in a list of 14 preliminary indicators for further development. The indicators are presented in order of importance:

- population pressure
- land cover change
- total grazing pressure
- soil erosion
- human poverty index
- rainfall index
- normalised difference vegetation index
- water consumption by resource type
- routine monitoring of water levels in non-strategic regional aquifers
- value added to water
- water quality within water resources
- economic diversification
- GDP spent on environmental resource research
- capacity to do regional and local land use planning.

A large number of criteria have been developed for evaluation of indicators, e.g., functionality, measurability, simplicity and sensitivity (OECD, 1993; Simmonett, 1998). Acknowledging these existing sets of criteria, five specific criteria were used for evaluation of the usefulness of indicators ranked by stakeholders, i.e., scientific relevance, data availability, accuracy/sensitivity, availability of historical data/time series and threshold values.

- The criterion of *scientific relevance*, evaluated underlying theory and assumptions made in defining the indicator and the indicator's relevance for monitoring land degradation. Scientific value was considered high if the indicator was based on sound assumptions and accepted causal relationships related to land degradation.

- The criterion of *data availability* was fulfilled if data required by an indicator were readily accessible and had coverage relevant to the indicator. Quality of data was not evaluated by this criterion.
- The criterion of *accuracy/sensitivity* was defined as,

  – how accurately the indicator measured and
  – how sensitive the indicator was to identify changes in conditions being monitored.

These are highly dependent on data accessibility, frequency and resolution of data collection and data quality. Aggregated data, e.g., livestock counts done on farm level being combined and presented on a regional level, has a negative influence on the sensitivity of an indicator. Indicators designed to monitor dynamic systems, requiring data of higher spatial and temporal resolution than what is presently accessible, were considered to have a low sensitivity/accuracy.

- The criterion of *availability of historic data/time series* was fulfilled if historic observations or time series with national coverage existed.
- The criterion of *threshold values* was fulfilled if there were any known target values that the indicator could be measured against.

For a suggested indicator to be accepted, it had to fulfil the criteria of scientific relevance and at least three of the remaining four criteria.

The indicators that fulfilled the requirements defined by the criteria were: 1. population pressure, 2. total grazing pressure 3. soil erosion, 4. rainfall index and 5. normalised difference vegetation index.

Four of the five indicators were further developed as primary indicators resulting in 1. population pressure index, 2. livestock pressure index, 3. rainfall index and 4. erosion hazard index. The normalised difference vegetation index (NDVI), recorded by the NOAA AVHRR sensor, was not included at this stage but will be used for evaluation of the resulting land degradation risk maps presented here.

3.2. Gather required data sets

A main constraint to the development of most national monitoring systems is the high cost involved in gathering data with national coverage. Most monitoring systems have to be based on already existing data, i.e., data that have been/are being systematically collected and documented throughout the country. This also applies to the monitoring system presented here. To avoid a data driven approach towards a situation where availability of data defined the indicators, potential indicators were defined before any data were collected. Data sets used for the calculation of the selected indicators are presented in the section below, where the definition and calculations of each indicator are outlined.

3.3. Develop a GIS-based system producing annual updates of the status of land degradation in Namibia

GIS tools were used to analyse the existing data sets and to transform multiple data layers into new information. All data sets were rasterised and converted to a resolution of 1*1 km. Arcview (ESRI, 2001) was used for preparation of vector data and Idrisi32 (Clark-Labs, 2000) was used for raster-based analysis. Initial thresholds for indicators were determined on the basis of literature and stakeholder consultations.

Calculations of the four primary indicators are outlined below. The Namib Desert along the western coast of Namibia has been excluded, as this area is a natural desert and therefore, not relevant to the land degradation monitoring system being presented here.

3.3.1. *Population Pressure Index*

Population pressure caused by population growth, and also unequal distribution of people, has been identified as an underlying cause of land degradation in rural areas of Namibia (Adams *et al*., 1990; Quan *et al*., 1994b). The link between increased population density and land degradation due to increased demand for firewood, clearing of vegetation for cultivation and grazing as well as browsing by livestock in Namibia's rural areas has been identified by Lange *et al.* (1997). On the basis of these findings it was assumed that increased density of people depending on natural resources leads to higher risk of land degradation. The opposite has been shown in other parts of Africa, e.g., Machakos district, Kenya (Tiffen *et al.,* 1994), but the assumption has been shown to be valid in Namibia (Lange *et al.,* 1997; MET, 1999). It was further assumed that an area with a longer growing period could sustain higher population pressure than an area with a shorter growing period (FAO, 1983).

MET (1999), originally developed the population pressure index. Data used were collected during the national census of 1991 (Central Bureau of Statistics, 1994). Four variables are calculated for the index: population density (people/km^2), percentage of population depending on firewood, percentage of population depending on agriculture and the dependable growing period. The dependable growth period (DGP) is defined as the length of the growth period being equalled or exceeded in 3 years out of 4 years and is used here as a measure of potential growth. The DGP was calculated on the basis of rainfall records and average potential evapotranspiration from 52 weather stations (Pauw and Coetzee, 1996). Threshold values for the index are presented in Table I. The annual population growth was calculated on the basis of an annual growth rate of 3.1% for the entire time series (1971–2001).

One weakness of this indicator is that it relies on population figures from only one national census carried out in 1991. The assumption of a constant growth rate of 3.1% per annum is an oversimplification of the actual situation, as the population growth rate might be higher or lower in different parts of the country. The index does not include any movements between regions and from rural to urban areas that have most likely taken place. When made available, the national census figures of

TABLE I
Threshold values for the population index after MET (1999). PD = population density, AD = % of population depending on agriculture and FW = % of population depending on firewood

Dependable growth period	High pressure	Moderate pressure
>85 days/year	PD > 15/km^2	PD > 10/km^2
	AD > 60%	AD > 50%
	FW > 80%	FW > 70%
>33 days/year	PD > 7/km^2	PD > 3/km^2
	AD > 50%	AD > 40%
	FW > 80%	FW > 60%
>6 days/year	PD > 3/km^2	PD > 1/km^2
	AD > 40%	AD > 30%
	FW > 70%	FW > 50%
= 0 days/year	PD > 1/km^2	PD > 0.5/km^2
	AD > 30%	AD > 20%
	FW > 60%	FW > 40%

2001 will give a more accurate picture of what the present situation is and what has happened during the past ten years.

3.3.2. *Livestock Pressure Index*

This index measures pressure by livestock in areas surrounding permanent water sources. Permanent water points, i.e., boreholes, taps, wells and perennial open water bodies, are focal points for grazing and other agricultural activities in Namibia's rural areas (Quan *et al.*, 1994b). Furthermore, it has been shown that if the numbers of cattle using a water point over an extended period of time exceeds the assessed local carrying capacity, land degradation is likely to occur (Fuls, 1992).

The index is based on annual livestock figures corresponding to the 15 State Veterinary Districts (SVDs) in Namibia. As it is impossible to know exactly where livestock are grazing, the index has to rely on some assumptions. As cattle under normal conditions seldom walk further than 7 km away from a water point, it was assumed that all cattle are within 10 km from any permanent water point. Furthermore, it was assumed that animals are evenly distributed within these areas.

Two main data sets were used: the distribution of boreholes in Namibia, collected by the Directorate of Water Affairs (DWA) and annual numbers of livestock per SVD. Data collected by the Northern Namibia Environment Program (NNEP) were used to complement the DWA database for water sources in north-central Namibia.

The number of cattle, sheep and goats counted within each SVD were used. Goats and sheep were recalculated into large stock units (LSU) by dividing the total number by 5.25 i.e., one head of cattle is equal to 5.25 goats (Herselman, 2000). For each SVD, livestock density was calculated by dividing the total area within 10 km from any borehole with the total number of LSU within each SVD.

TABLE II
Threshold values used for calculation of the livestock pressure index. The numbers represent hectares/large stock unit (Ha/LSU)

Class	DGP = 0 days	DGP > 6 days	DGP > 33 days	DGP > 85 days
Very high	7	5	4	3
High	10	8	6	4
Moderate	20	16	12	8
Low	40	32	24	16
Very low	60	48	36	24

The dependable growth period was used as a measure of potential carrying capacity. Four classes were defined for dependable growth period, i.e., 0 days, > 6 days, > 33 days and > 85 days. The threshold values used are presented in Table II.

3.3.3. *Rainfall Index*

Rainfall is one of the most important factors influencing environment in Namibia (Leggett *et al.*, 2002; Ward *et al.*, 1998). Rainfall in Namibia is characterised by the lowest annual mean rainfall in the south and along the coast, increasing towards the northeast. Areas with low annual rainfall experience higher annual and inter-annual rainfall variability compared to areas with higher annual rainfall (Dealie *et al.*, 1993; Olszewski and Moorsom, 1995; Heyns *et al.*, 1997). To calculate this index, it was assumed that areas with low annual rainfall and high variability have a higher risk of land degradation than areas with higher annual rainfall and lower variability.

The index is based on rainfall records from the Namibian Weather Bureau that have been corrected by the Directorate of Environmental Affairs (DEA) for MAWRD (MAWRD, 1999). It should be noted that data for the period 1998–2001 are outstanding. Data have been reported to the Namibian Weather Bureau, but have not yet been made available.

Long-term medians for each rainfall station and standard deviations were used to interpolate a median and a standard deviation map of Namibia. The rainy season normally starts in October and ends in April (Olszewski and Moorsom, 1995). Yearly rainfall maps were produced by interpolating the total rainfall recorded at each rainfall station between September and August the following year, for the period 1970–1997. The index was calculated by the following formula:

$\text{Rainfall Index}_{(\text{year x})} = (\text{Total rainfall}_{(\text{year x})} - \text{long term median})/\text{standard deviation}$

The threshold values used are presented in Table III.

The long delay from the collection of rainfall data until they are made available is a limiting factor to this index, making it impossible to do timely assessments of land degradation. A second complication is that the number of operational rainfall stations is continuously decreasing in Namibia, which is already having a negative effect on the accuracy of the index.

TABLE III
Threshold values used for the rainfall index, SD = standard deviation

Risk class	Threshold
Very high	<-1.5 SD
High	-1.5–<-0.5 SD
Moderate	-0.5–0.5 SD
Low	>0.5–1.5 SD
Very low	>1.5 SD

TABLE IV
Soil types identified according to the FAO Soils Units and Fertility Capability Classification (FCC) and hazard classes defined according to Pauw and Coetzee (1996)

FCC class	Soil type	Hazard class
L	Loamy (>35% clay but not loamy sand or sand)	High
LR	Loamy with rocks or other hard root-restricting layer	Low
S	Sandy	Low
Se	Sandy with low capability to provide nutrients to plants	Moderate
She	Sandy, low capability to provide nutrients and presence of soil acidity	Moderate
SLe	Sandy loamy with low capacity to provide nutrients	Moderate
SRdb	Sandy with rocks, dry soils (associated with very dry moisture regimes), basic reaction indicated by CaCO3 or pH >7.3)	Low
Ss	Sandy with presence of soluble salts	High

3.3.4. *Erosion Hazard Index*

This index is based on the assumption that gradient and soil characteristics influence the rate of soil erosion by both wind and water. The data set used has been developed by Namibia’s Agro-Ecological Zones Project (Pauw and Coetzee, 1996). Soil erosivity was determined on the basis of gradient and soil characteristics for each agro-ecological zone. Agro-ecological zones are considered to be the land entities that are sufficiently uniform in terms of climate, landform and soil features for broad planning objectives and are unique by specific combinations of these land attributes (Pauw and Coetzee, 1996). Three gradient classes were defined: low: 0–8°, moderate: >8–15° and high: >15°. Soil types were based on the UN Fertility Capability Classification (FCC) (FAO, 1983). Soil types and corresponding hazard classes are presented in Table IV. The erosion hazard index was calculated by combining gradient and soil maps.

3.3.5. *Land Degradation Risk Map*

Data were available for all four indicators for the period 1971–1997. Annual degradation risk maps were calculated by combining the four indicators (Figure 2).

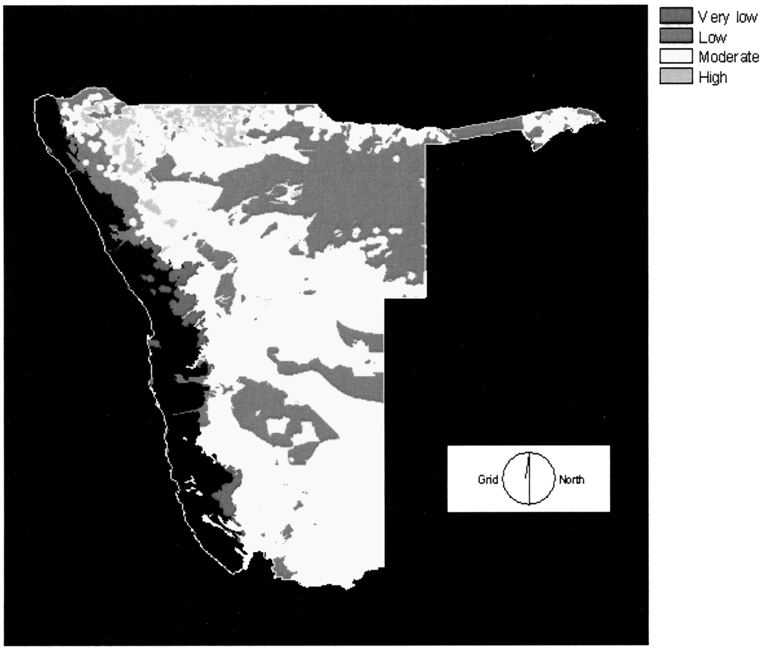

Figure 2. Land degradation risk map for 1997 based on the four indicators described.

The population pressure index has only three classes according to its definition. The class values 2 (moderate) and 3 (high) were modified to 3 and 5, i.e., moderate = 3 and high = 5. Definition of the resulting five-land degradation risk classes: very low, low, moderate, high and very high is given in Table V.

4. Time Series Analysis of the Indicators

A time series analysis was done over the period 1971–1997 for the rainfall index, livestock pressure index, population pressure index and the combined degradation

TABLE V
The relationship between individual indicators and the resulting land degradation risk map. For each class, very low = 1, low = 2, moderate = 3, high = 4 and very high = 5

Degradation risk class	Population	Livestock	Rainfall	Erosion	Range
Very low	1	1	1	1	1–4
Low	1	2	2	2	5–7
Moderate	3	3	3	3	8–12
High	5	4	4	4	13–17
Very high	5	5	5	5	18–20

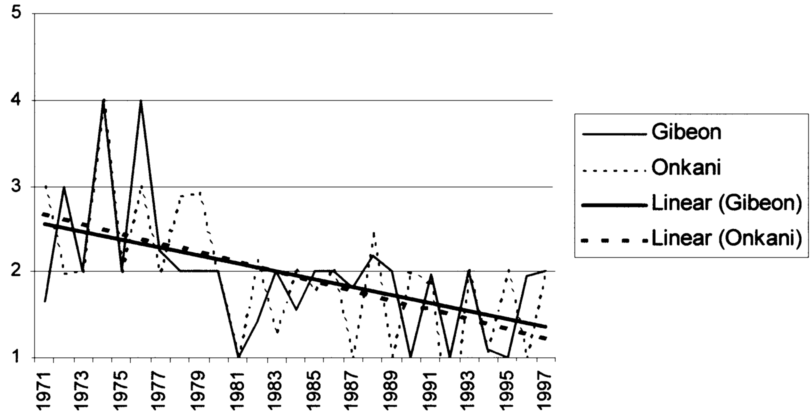

Figure 3. Change over time for the rainfall index at two test sites during the period 1971–1997. Value 1 =< (−1.5) SD, 2 = (−1.5) SD − < (−0.5) SD, 3 = (−0.5) SD −0.5 SD, 4 => 0.5 SD −1.5 SD and 5 => 1.5 SD. Both Onkani and Gibeon have had a negative trend in rainfall during the period, i.e., larger negative deviation from long-term median in later years.

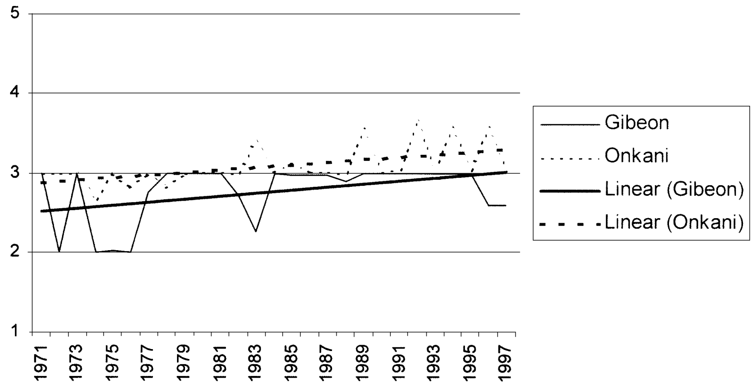

Figure 4. Change over time for the combined land degradation risk index at the two test sites during the period 1971–1997. Value 1 = very low risk, 2 = low risk, 3 = moderate risk, 4 = high risk and 5 = very high risk. Risk for land degradation is higher in Onkani than in Gibeon, but both sites show a trend towards increasing risk.

risk maps. Two study sites were selected, Onkani in north-central Namibia and Gibeon in the south. The study site in Onkani has an area of approximately 4800 km^2, and Gibeon approximately 7600 km^2 (Figure 1). These two sites are pilot sites for Napcod, where both biophysical and socio-economic surveys have been conducted. The purpose of this analysis was to identify whether there were any trends in the time series. The linear trend line was calculated by using the method of least squares. The results are presented in Figures 3 and 4.

Onkani experienced a low population increase from the 1970s to 2001, while Gibeon shows a much steeper increase, indicating that Gibeon had a higher population than Onkani at the start of the calculation, as all values are extrapolated with a constant population increase of 3.1% per annum for the period 1970–2001. Recent fieldwork in the Onkani area showed that the population has increased more rapidly since 1992 when a fresh-water pipeline was installed providing people and livestock with a permanent supply of water (Akawa *et al.*, 2002).

The livestock index shows that livestock numbers in Onkani have increased steadily since 1992, while livestock numbers in Gibeon show a slight decrease over the same period. Both Gibeon and Onkani had an increase in livestock numbers in 2000, which could be in response to favourable conditions during the period 1998–2000, when large parts of Namibia received above average rainfall.

The rainfall index shows a decrease in rainfall for both sites over the period under consideration (Figure 3). The combined land degradation risk map indicates that increased risk of land degradation in Onkani is mainly caused by increase in livestock pressure and a negative rainfall trend (Figure 4). In Gibeon, the increased land degradation risk is caused by the increase of population pressure and negative rainfall trend.

The results relate to observations at the two sites. Although other findings indicate a higher population increase in Onkani, the area still has a very low population density. These preliminary findings will be verified through continued field evaluations, where results can be tested against the actual situation at the sites.

5. Discussion and Conclusion

This paper presented results of a process leading to the development of primary indicators for a first approximation of land degradation monitoring in Namibia. The process has illustrated a number of experiences relevant to other developing countries, as well as international agencies attempting to contribute to understanding and monitoring of land degradation.

Several key steps for development of relevant land degradation indicators, applicable for national level monitoring, have been identified,

1. It is important that those involved in the identification of indicators have an overall understanding of both socio-economic and biophysical key elements of land degradation impacts.
2. A set of well-defined criteria is required to ensure relevance and usefulness of indicators being developed. Based on our experience from Namibia, we suggest that development of criteria be done on an international level to ensure that a globally accepted set of criteria will be made available.
3. Accessibility of data is fundamental for the functioning of any monitoring system. Many indicators proposed by Namibian stakeholders were inappropriate as data were not being collected or could not be collected for various reasons involving funding, manpower and inflexible sectoral programmes.

In our experience, a major thrust on the international level is the development of a set of core desertification indicators that would be universally applicable. The Namibian experience however, underlines the importance of developing specific indicators applicable on a national level. There are several benefits to this:

1. There are no universal causes or effects of land degradation.
2. The participatory approach gave stakeholders ownership of the process and the resulting indicators, and led to an increased understanding of the concept of environmental monitoring.
3. A common platform was established for stakeholders from various sectors, leading to an increased interaction between sectors, an important aspect in most developing countries, where sectoral approaches predominate.

The target group for the Namibian national level monitoring system is mainly decision makers on national and regional levels. Accuracy of indicators has to be determined, as decisions taken based on the results are likely to have an influence on both national and local levels.

Finally, land degradation is a multi-faceted phenomenon with many causes and effects. It is clear that the four indicators presented here are not sufficient to provide a complete picture of land degradation risk in Namibia. The first approximation presented here should rather be seen as a first national monitoring system developed in a fully participatory manner, involving stakeholders from all levels. To improve the monitoring system, the four indicators have to be tested and evaluated in the field and additional indicators developed.

6. Abbreviations

CCD	Convention to Combat Desertification (UN)
CEROI	Cities Environment Reports on the Internet
CIESIN	Center for International Earth Science Information Network
DEA	Directorate of Environmental Affairs (Namibia)
DGP	Dependable Growth Period
DPSIR	Driving forces, Pressure, State, Impact and Response framework
DWA	Directorate of Water Affairs (Namibia)
FAO	Food and Agriculture Organisation (UN)
FCC	Fertility Capability Classification
GIS	Geographical Information Systems
LSU	Large Stock Unit
MAWRD	Ministry of Agriculture, Water and Rural Development (Namibia)
MET	Ministry of Environment and Tourism (Namibia)
NAP	National Action Plan

Napcod	Namibia's Programme to Combat Desertification
NDVI	Normalised Difference Vegetation Index
NOAA AVHRR	National Oceanic and Atmospheric Administration Advanced Very-High Resolution Radiometer
OECD	Organisation for Economic Co-operation and Development
PSR	Pressure, State and Response framework
SVD	State Veterinary Districts
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environmental Programme

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