Local and national perceptions of land degradation in the Ombuga grasslands, northern Namibia

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Abstract

A national level land degradation monitoring system identifies the Ombuga grasslands in northern Namibia as an area experiencing an increased risk of land degradation. A time series analysis of annual results from this monitoring system for the period 1971-1997 concludes that increase in livestock pressure and a negative rainfall trend are main causes. To validate these findings, interviews were held with representatives from four communities in and near the Ombuga grasslands on their perceptions of the state of their local environment. Results show that interviewed farmers regard land degradation as occurring in the area. Decreasing rainfall and increasing livestock numbers were identified by farmers as the main causes of perceived degradation. A conceptual model is presented, indicating that rainfall variability, introduction of pipelines providing permanent access to fresh water and slow introduction of regional councils, leaving the traditional authorities with limited control of the resources, are the main causes of perceived degradation. Analysis of annual rainfall records from four rainfall stations within a radius of 100 km from the area of interest, for the period 1930-2000 shows a decrease in rainfall since the early 1990s, supporting statements made by interviewees. However, it was also shown that the present period of lower rainfall is not unique and that drier periods are part of the normal conditions. These findings do not contradict results from the national monitoring system. A survey of the extent of actual land degradation in the Ombuga grasslands is the next step to further evaluate results from national level monitoring and interviews presented here.

Keywords

Namibia, land degradation, monitoring, local knowledge, semi-arid, grazing, rainfall variability

Introduction

Land degradation in arid and semi-arid parts of the world, often referred to as desertification, has been regarded as a major environmental problem for more than 20 years (Dodd, 1994; Swift, 1996; Glenn et al., 1998). The UN definition of desertification states that desertification is land degradation in arid, semi-arid and dry sub-humid conditions, caused by various factors, including climatic variations and human activities (UN, 1992). Swift (1996) defined dryland degradation as a persistent decrease in the productivity of vegetation and soils, brought about largely by inappropriate land use leading to physical changes in soil and vegetation structure, irrespective of levels of rainfall or soil moisture.

While some researchers state that the problem of desertification is universal (UN, 1992; Cardy, 1993; Kassas, 1995), others question the assumptions, methodologies, evidence and scale upon which these statements are based e.g. (Binns, 1990; Hellden, 1991; Agnew & Warren, 1996; Swift, 1996; Sullivan, 2000). Some disagreement is likely to arise from the fact that several different processes and pathways can bring about degradation and desertification. In addition, many assessments of rate and extent of desertification have been highly academic and often based on short term field investigations (Leach & Mearns, 1996a). There are several examples of drylands assumed to have been degraded showing a dramatic resilience, recovering as soon as rainfall conditions improve (Hellden, 1991; Agnew & Warren, 1996; Swift, 1996). Systems responding like this, often referred to as non-equilibrium systems, are thought to be driven primarily by stochastic abiotic factors, e.g. highly variable rainfall, characteristic of semi-arid and arid environments, which results in highly variable and unpredictable primary production (Westoby et al., 1989; Behnke & Scoones, 1993; Scoones, 1995). There has been a lack of studies linking scientific investigations with local knowledge (Leach & Mearns, 1996b; Swift, 1996; Sullivan, 2000). However, several authors have drawn attention to the importance of local knowledge and perceptions for improved understanding of often complex systems in arid environments (Swift, 1996; Norton et al., 1998; Verlinden & Dayot, 2000; Gray & Morant, 2003; Osbahr & Allan, 2003).

Monitoring of land degradation in Namibia

Namibia signed the UN Convention to Combat Desertification in 1994 and ratified it in 1997 (Bethune & Pallett, 2002). Namibia's Programme to Combat Desertification (Napcod) was initiated 1994 and is presently in its third phase. A major activity in the present phase is to develop a national land degradation monitoring system (Klintenberg & Seely, 2003). The system that has been developed is based on four primary indicators; population pressure, livestock pressure, rainfall amount and variability, and erosion hazard. By combining these four indicators, annual land degradation risk maps have been produced for the period 1971 to 1997.

Aim

The aim of this study, carried out at four communities in and near the Ombuga grasslands, central northern Namibia, is to investigate local farmers' perceptions of the state of their local environment, and to compare these to results from Napcod's national level land degradation monitoring system and data gathered from other sources.

Study area

Four communities in and around the Ombuga grasslands, Uuvudhiya, Lake Oponono and Omapale in Uuvudhiya constituency in Oshana region; and Onkani, in Okahao constituency, Omusati region, were selected for this study as these communities are situated in an area that has been identified by the national level land degradation monitoring system as having a high risk of being degraded (Klintenberg & Seely, 2003). The area being investigated covers about 1,600 km^2 and is situated at approximately 1100 m above sea level (Fig. 1).

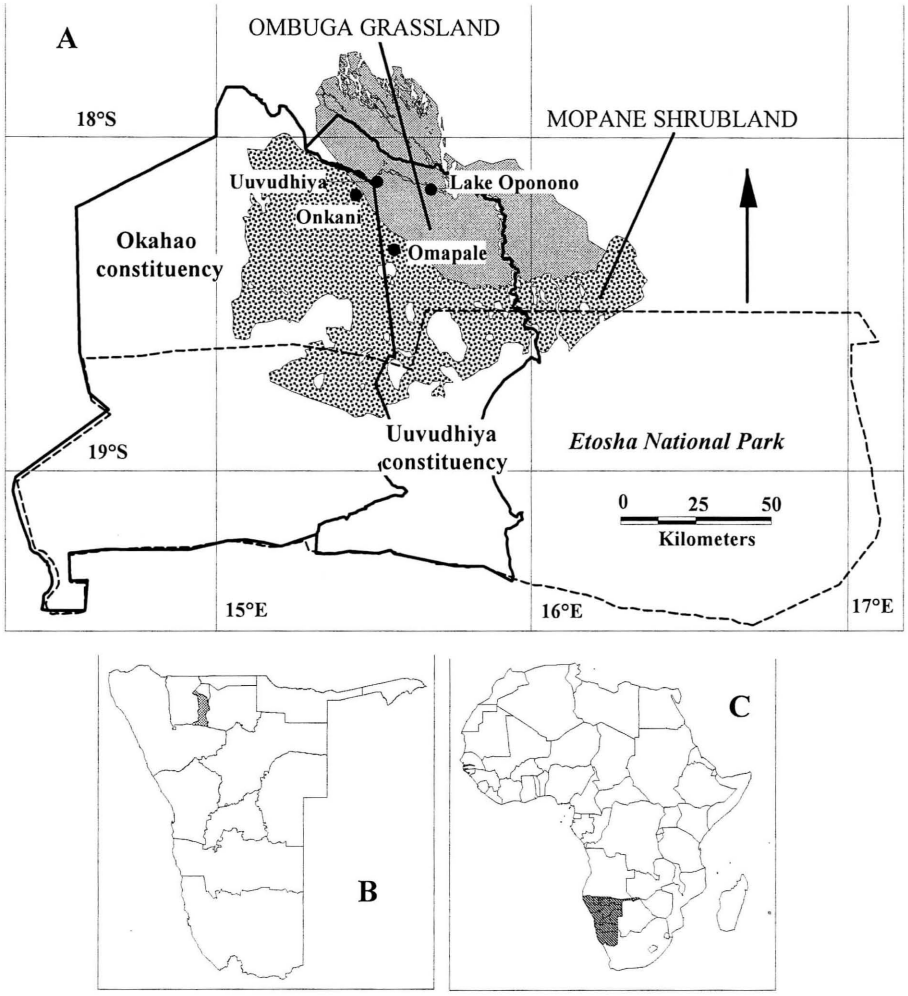

Figure 1. Map A shows the location of the four communities visited. Map B shows the location of Uuvudhiya constituency in Namibia and Map C shows Namibia on the African continent.

Biophysical conditions

Geologically the Ombuga grasslands and surroundings belong to the Kalahari sequence, reaching a thickness of up to 500 m of semi- to unconsolidated sediments (Thomas & Shaw, 1991). Soils of the Ombuga grassland consist of clayey sodic sands in the lower lying parts of the landscape and sodic sands on surrounding higher ground (Mendelsohn et al., 2000). The soil is not very fertile, characterised by a high sand fraction (Marsh & Seely, 1992). The area typically has sandy topsoil, about 20 cm thick, underlain by a saline hardpan forming very distinct prismatic structures. The prismatic structure is

characteristic of a natric B-Horizon, i.e. an indicator of salinity (Duchaufour, 1982; FAO-UNESCO, 1988).

The climate is semi-arid and the area receives an average annual precipitation of approximately 350 mm in the southwest and 450 mm in the northeast (Fig. 4). The rainfall is patchy and highly variable in time and space. The rainy season normally starts in October and ends in April (Olszewski & Moorsom, 1995). The monthly mean temperature ranges from 26 °C in November to 16 °C in July. During the coolest period the night temperature drops to 7 °C while day temperatures rise to 27 °C or higher (Erkkilä, 2001). Evaporation is very high throughout the year. The annual potential evaporation is approximately 2500 mm, exceeding the annual precipitation by a factor of about five (Mendelsohn et al., 2000).

Two distinct vegetation types occur in the study area, saline Ombuga grassland and mopane shrubland. Perennial grasses dominate undisturbed parts of the grassland as the shallow salty soils prevent growth of woody species (Mendelsohn et al., 2000). The shrubland is dominated by *Colophospermum mopane* Kirk ex Benth., reaching a maximum height of about 2.5 m. Larger trees may occur in areas where the soils are deeper and less saline. Onkani and Omapale are located in the mopane shrubland, just outside the grassland, while Uuvudhiya and Lake Oponono are in the grassland (Fig. 2)

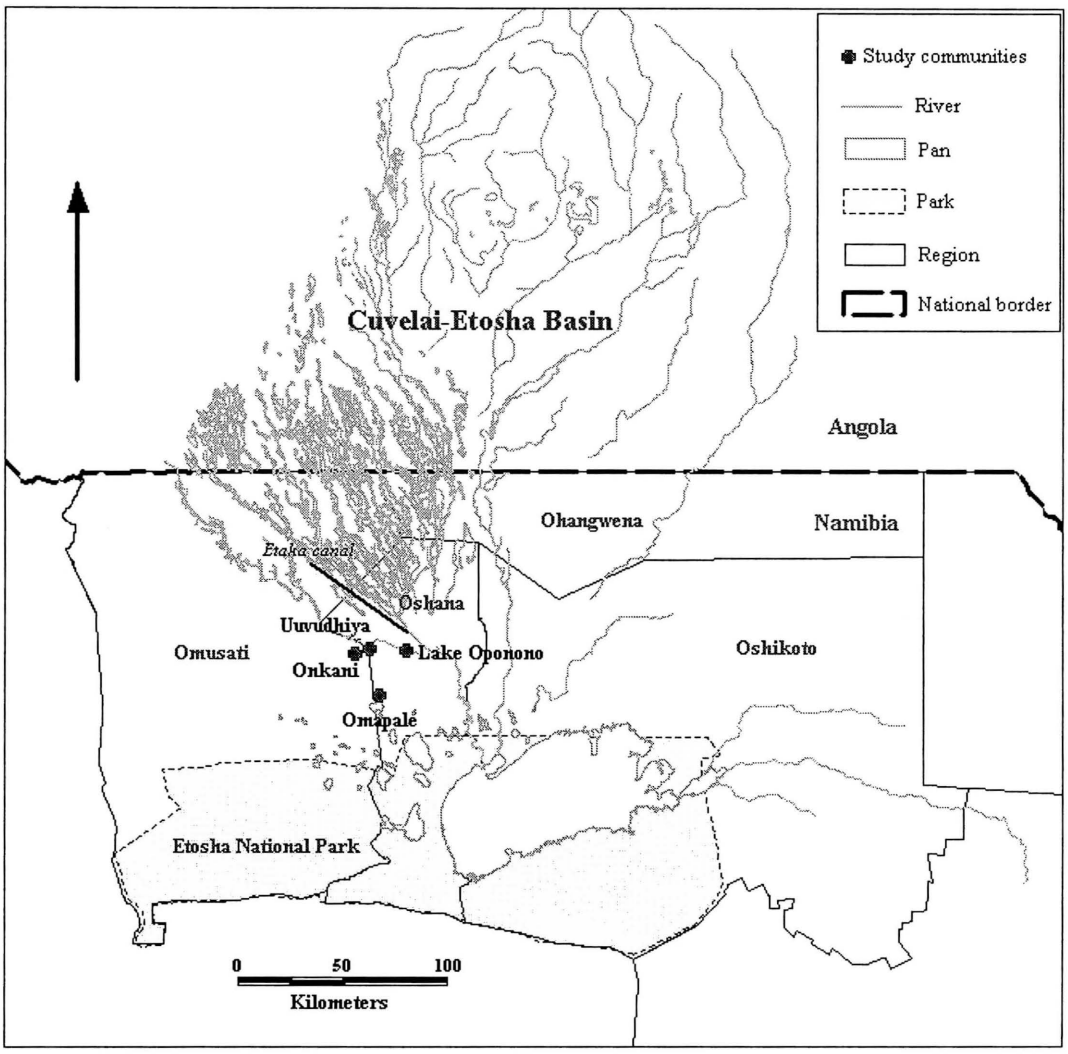

Figure 2. The map shows the extent of the Cuvelai-Etosha basin and the location of the four communities where interviews were done.

Central northern Namibia falls within the Cuvelai-Etosha basin (Christelis & Struckmeier, 2001). Perennial tributaries occur only in Angola (Fig. 2). About 80 km south of the Angolan border, watercourses converge into the Etaka Canal, which drains into a shallow semi-permanent system of interconnected lakes and pans and then into Etosha pan (Erkkilä, 2001). Due to the flat character of the landscape in central northern Namibia and the poor infiltration owing to the hard pans, a large number of shallow, ephemeral, poorly defined but interconnected flood channels (oshanas) and pans occur (Christelis & Struckmeier, 2001). In the Ombuga, surface water flows slowly in these

channels or may form pools depending on the intensity of floods. During the rain season and early dry season the oshanas serve as fresh water reservoirs, providing drinking water for humans and livestock. Later in the season when dried up, they are used for grazing (Marsh & Seely, 1992). Neither surface water nor ground water sources in the area provides large volumes of water. The groundwater is highly saline with TDS ranging from 30 000 to 100 000 mg/L and chloride concentrations are 10 000-40 000 mg/L (Christelis & Struckmeier, 2001). Being an inland drainage system, the salt content of soil and water tends to increase as salt is continuously added to the system by water flowing into the area and concentrated by evaporation (Marsh & Seely, 1992).

A pipeline system was constructed in 1992/93 to supply safe water to within 2.5 km of households in Onkani and Uuvudhiya settlements (Mendelsohn et al., 2000; Christelis & Struckmeier, 2001). The pipeline also extends into the less populated southern parts of the Ombuga grassland and onto the shrubland, providing livestock with permanent water supply at evenly spaced water points (Fig 5). Omapale is the southern most community along the pipeline. The introduction of a reliable water supply has led to a marked increase of livestock numbers and encouraged people to settle permanently in the vicinity of these water points, often in areas that are unsuitable for permanent settlement and sedentary livestock farming (Erkkilä, 2001).

Socio-economic conditions

The total population in Namibia is about 1.8 million, of which approximately 50% are settled in the central northern regions (NPC, 2002). As a result of population growth and increasing human settlement during the past century, natural resources of central northern Namibia are presently under high pressure (Quan et al., 1994). In 1994 an estimated 68% of the Namibian population derived at least part of their livelihood from agriculture (Kruger, 2001).

Before the late 1960s the Ombuga grasslands were sparsely populated by San and Ovahimba semi-nomadic pastoralists (Erkkilä, 2001). The first permanent settlements in and around the Ombuga grasslands were established in 1968 (Christelis & Struckmeier,

2001) centred around hand dug wells. Population numbers were low until the beginning of the 1990s, when a rapid increase led to the present population of approximately 4,400 (NPC, 2002). This rapid population increase coincides with the construction of the water pipeline. No information is available about the present population of the four communities Onkani, Uuvudhiya, Omapale and Lake Oponono. According to the national census of 1991 the communities fall within two enumeration areas where a total of 1075 people were living (Central Bureau of Statistics, 1994). It can be assumed that about a third to half of the total population of the two enumeration areas were living in the four communities at the time of the 1991 census. The vast majority of farmers now permanently living in and around the Ombuga grasslands are small-scale farmers (Fuller & Turner, 1996; Werner, 2002). Subsistence agriculture and pastoralism are the main land uses in the area. Each homestead has a crop field where pearl millet (mahangu) is the main crop, supplemented with sorghum and various beans. Animals are raised under extensive ranching conditions, relying on natural pastures (Fuller & Turner, 1996; Werner, 2002). For most of the year the bulk of the herds is kept at cattle posts in the Ombuga grassland, where they get water from oshanas (during and just after the rain season) and at permanent water points along the water pipeline. A cattle post is a temporary dwelling occupied by one or several herders, located in an area where livestock have access to water and grazing. Animals are normally kraaled at the cattle post every night. Herding is normally performed by a member of the homestead or by hired labour. Most homesteads do not produce any surplus for sale (Fuller & Turner, 1996).

The Uuvudhiya and Okahao constituencies are under the communal tenure system, i.e. the land is owned by the Government and is in principle accessible to anyone but with no exclusive rights. The Ombuga grassland is among the rapidly decreasing open access grazing areas in central northern Namibia, which has led to an increased number of cattle from other parts of northern Namibia grazing in the area, and a large number of new cattle posts being established (Low et al., 1997; Denker & Schalken, 1998; Denker & Schalken, 1999). Before independence in 1990 the access to natural resources and land management was controlled by local traditional authorities (Verlinden & Dayot, 2000). In

1992 Regional Councils were established in terms of the provisions of the Regional Councils Act, 1992 (Werner, 2002). These councils were aimed at decentralising rural development, planning and policy implementation and to give farmers the opportunity to participate in the overall development of their respective areas (Werner, 2002). However, the implementation has been slow. Unclear divisions of authority between traditional authorities and the regional council has left traditional authorities with limited, largely informal control over establishment of homesteads, crop fields and cattle posts. The situation of unclear authority has in many instances led to people settling without consulting the local authorities. This has also led to conflicts, as large areas of the Ombuga grassland are now being illegally fenced off for private, exclusive use.

Methods

Interviews

Individual semi structured interviews were held with representatives of Lake Oponono, Omapale, Onkani and Uuvudhiya communities between 24 April and 2 May, 2003. The questions asked focused on the present state of the environment and changes in environmental conditions in the area and, if changes were noted, what perceptions do the people have about causes and effects of these changes. Initially a group discussion was held with representatives from local communities, extension officers from the Ministry of Agriculture, Water and Rural Development (MAWRD), two non-governmental organizations and visiting researchers. At this meeting concepts of environmental change and land degradation were discussed and clarified. A total of 10 individual interviews were conducted with farmers living at the four communities. All respondents are associated to a local community based organisation with a focus on rangeland and livestock issues. Representatives were selected based on previously demonstrated good knowledge of the environmental conditions in the Ombuga area. Table 1 indicates information about the interviewee's gender, position in the community, location and when he/she settled in the area. A map of the study area, showing the location of settlements, cattle posts, water points and access roads, was used as the basis for the interviews. During the group discussion and the individual interviews all respondents were asked to indicate on the map where in the study area they have identified changes in the state of the environment. A second visit was paid to the study area 9-10 June 2003

when results from the interviews were discussed and checked with members of the communities.

Table 1. *Information about interviewee's gender, position in the community, location and year when interviewee settled in the area.*

Gender	Position	Location	Settled in area
Male	Headman	Lake Oponono	1971
Female	Farmer, head of household	Onkani	1972
Male	Senior headman	Onkani	1977
Female	Farmer	Onkani	1978
Female	Farmer, head of household	Onkani	1978
Male	Deputy headman	Onkani	1978
Male	Farmer, head of household	Lake Oponono	1983
Male	Herder	Omapale	1993
Male	Herder	Omapale	1993
Male	Farmer, head of household	Uuvudhiya	1993

As will be shown in the results below, the interviewees indicated that decreasing rainfall and a dramatic increase in livestock numbers are the main causes of land degradation in the study area. Subsequently independent rainfall data were used to evaluate these statements. No reliable livestock data was accessible for the area under investigation, which prevented any further evaluation of the statements regarding livestock in the area.

Determining land degradation risk by using Napcod's national land degradation monitoring system

The methodology of calculating the national land degradation risk index developed by Namibia's programme to combat desertification was presented in (Klintenberg & Seely, 2003). For this study annual maps showing risk of land degradation were combined into two average maps, i.e. two map showing average conditions between 1986 and 1991 and average conditions between 1992-1997.

Analysis of rainfall data

Annual rainfall records from four meteorological stations situated outside the study area (Ombalantu, Oshikuku, Okatana and Okaukuejo) were used to assess if any significant changes in rainfall have occurred during the period September 1930 to August 2000 (Fig. 3). The rainfall year in the study area starts in September and ends in August the following year (Olszewski & Moorsom, 1995).

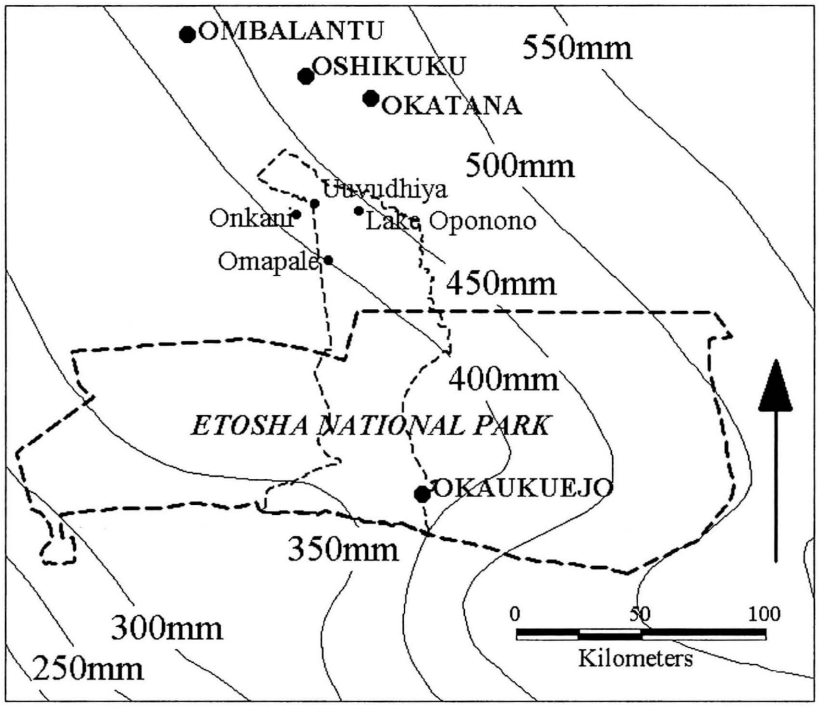

Figure 3. Location of the four rainfall stations, Okaukuejo, Okatana, Oshikuku and Ombalantu, used for the rainfall analysis. There is no rainfall station in the area being investigated, and the four stations are the only stations in the vicinity of the study area with data for the entire time period being investigated. Isohyets are interpolated from approximately 260 rainfall stations covering the country.

Rainfall records were smoothed by calculating a 9-year moving average. This procedure filters out year-to-year variations to reveal long term-trends (Wheeler & Martin-Vide, 1992; Salinger et al., 1995). The normality of the data was tested by using Shapiro Wilk's W-test (Shapiro et al., 1968). Due to non-normal distribution of the data the non-parametric Mann-Whitney U test was used for analysing the time series (Siegel, 1956).

Results

Perceptions of land degradation

According to the interviewees, land degradation equates to decrease in productivity of the land, e.g. decreased availability of fodder for livestock and lowered yields from crop fields. Productivity of the land was perceived to have decreased since the beginning of the 1990s. All respondents stated that land degradation is a problem in the study area. Seven interviewees responded that the most widespread manifestation of land degradation is change in grass species composition. Palatable perennial grasses, e.g. *Panicum maximum* (Jacq.) and *Schmidtia pappophorides* (Steudel), have decreased or completely disappeared from the area, being replaced by less palatable perennial grasses, palatable and unpalatable annual grasses and weeds. Grasses that are used by local farmers as indicators of rangeland condition are presented in Table 2. Three interviewees stated that perennial grasses come back when the rains are early and plentiful but that they are less abundant than before. According to the two interviewees at Lake Oponono the number of bare patches in the rangeland is increasing there.

Table 2. *Grass species used as indicators of grazing value by local farmers (n=7). Scientific assessment after (Muller, 1984; Oudtshoorn, 2002)*

Vernacular name	Scientific name	Type	Local assessment	Scientific assessment
Onnamume	*Eragrostis viscosa* (Retz.) Trin.	Annual	Low grazing value, not good for the livestock's digestion system	Hard, unpalatable grass with a low leaf production, seldom grazed.
Oshinamume	*Schmidtia kalahariensis* Stent	Annual	Relatively high grazing value. Blows away during dry season	Grazed before flowering stage and later, when dry. High nutritive value.
Omunamaidhi	*Aristida stipioides* Lam.	Annual	Low grazing value and awns get into eyes of livestock	Practically worthless for grazing
Olukateko	*Pogonarthria fleckii* Hackel	Annual	Not important for grazing	Hard unpalatable grass with low leaf production. Seldom consumed by grazers
Ongwena	*Odyssea paucinervis* (Nees) Stapf	Halophytic perennial	Good for grazing.	Little value for grazing. Consumed only while it is still young
Ombindangolo	*Eragrostis trichophora* Cosson & Durand	Perennial	Good for grazing Decreasing in the area	Consumed only in the absence of other, more palatable grasses. Produces little leaf material
Oshimombwe	*Dactyloctenium aegyptium* (L.) Beauv	Annual	Good for grazing Decreasing in the area	A palatable grass but seldom abundant enough to be a valuable grazing grass

The farmers' local assessment of grass quality presented in table 2 corresponds well with the scientific assessment of four of the seven species. However, the farmers regard *Odyssea paucinervis, Eragrostis trichophora* and *Dactyloctenium aegyptium* to be good for grazing, while the scientific literature refers to these species as being of low grazing value. This emphasizes the fact that grasses and grazing in Ombuga are of generally poor quality, as farmers' rate these three grass species as being good for grazing, as they are "the most palatable grasses in the area", even though their palatability is comparatively low.

Occurrence of land degradation

During the community meeting and the individual interviews all respondents were asked to indicate on a map where in the study area they have identified changes in the state of the environment (Fig. 4).

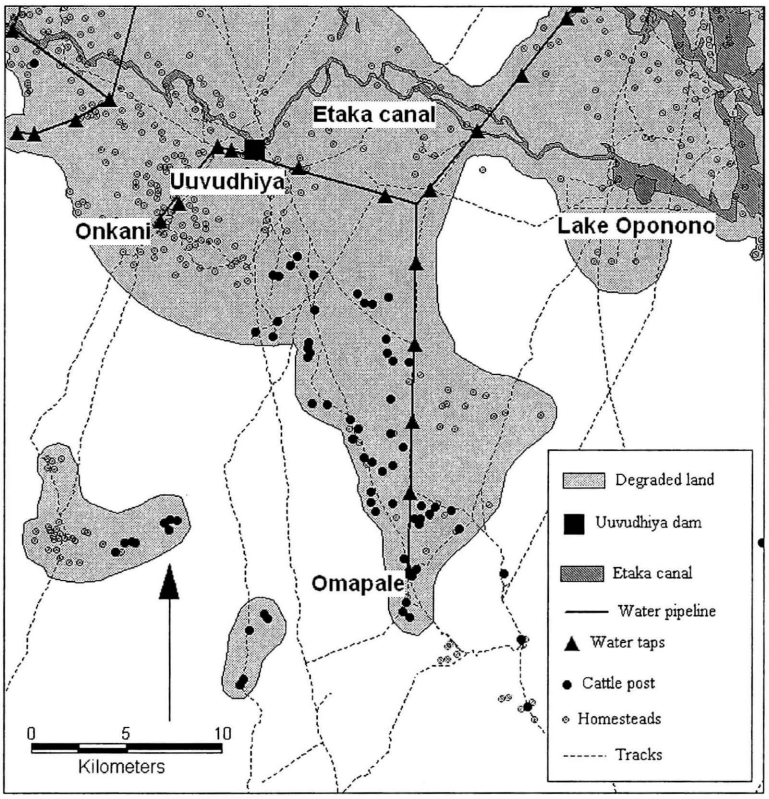

Figure 4. The grey areas outline the areas that were identified by the interviewees to be degraded. Source of GIS data: Northern Namibia Environmental Project (NNEP).

Environmental changes identified by the interviewees were all said to be related to land degradation. None of the interviewees indicated that there were any areas in which the state of the environment is improving. The resulting map of environmental change can therefore be regarded as a map of perceived land degradation in the area of interest. All respondents stated that the worst land degradation occurs at and around permanent water sources, i.e. at water points along the pipeline and around dams, especially the dams at Uuvudhiya settlement. The farmers in Uuvudhiya and Onkani settlements said that land within an approximate range of 10 km from the Uuvudhiya dams shows signs of degradation. Cattle from all over the Ombuga and beyond come to the Uuvudhiya dams when water in the grasslands has dried up. Two farmers at Lake Oponono said that the area south west of Lake Oponono is showing signs of land degradation, i.e. heavy grazing has led to loss of palatable grasses and increased occurrence of bare patches. They also said that when the lake is dry, all livestock in the area moves to water points along the pipeline. Land degradation was also said to occur within and nearby homesteads, where the main form of degradation is loss of palatable grasses that are replaced by weeds.

Causes of land degradation

All interviewees indicated that decreased rainfall during the last 10 years is the main cause of land degradation in the area. According to respondents, rainfall in Uuvudhiya constituency has decreased and become more irregular since the beginning of the 1990s. One interviewee said that rainfall has been irregular even since 1974 (one of the highest rainfall years in the past century). The same interviewee stated that the area has received very little rain the last six years.

An increased number of livestock in the Ombuga grasslands, leading to higher grazing pressure, was stated to be the second most important cause of land degradation. According to interviewees, the number of livestock in Uuvudhiya constituency has increased dramatically since 1990 in response to a rapid increase of human population during the same period. The number of cattle posts has also increased recent years. Several respondents stated that people from all-over northern Namibia and even Angola are now establishing cattle posts in the Ombuga grasslands. It was said to be a problem as

the newly established cattle posts are located very close to permanent water points, often less than 1 km from the water source. The reason for this being a problem was not clear, but it is not only an environmental problem, i.e. additional livestock further increasing the pressure on resources already being degraded, but also a cultural concern. Farmers establishing cattle posts as close as 1 km from a permanent water source have most likely not approached the local traditional authorities, as cattle traditionally are kept further away from permanent water sources. In similar areas nearby, encroaching farmers have subsequently enclosed government established water points for their private use.

Illegal fencing, i.e. demarcation of land areas for private use, is also perceived to cause land degradation in the area. The size of individual fenced off areas was said to range from 50 to 700 hectares. These fences prevent free movement of livestock and cause degradation (trampling and heavy grazing) outside the fences as large numbers of livestock now have to pass through narrow corridors to reach water points.

Other factors that were said to cause land degradation in the area are: increasing number of tracks and access roads, deforestation and too many donkeys. Five respondents stated that the increasing number of tracks and access roads has led to increased erosion, mainly water erosion during the rainy season. One interviewee stated that deforestation is the most important manifestation of land degradation. When she arrived in the area in 1978 there were many tall trees bordering the Ombuga grasslands but since then the number of trees is decreasing due to felling, as people require wood for cooking and construction of houses. The situation in areas bordering the area of interest seems to be even worse as it was stated that people living far away are coming there to cut trees and collect wood. One farmer said that the number of donkeys in the area is too high. According to this farmer, donkeys are more destructive than cattle as they eat all the time, not allowing grasses to rest.

Land degradation risk according to Napcod's national monitoring system

National land degradation risk maps with a resolution of 1 by 1 km have been produced by combining results of the four indicators presented in the introduction of this paper, for

each year for the period 1971-1997. An analysis of resulting land degradation risk maps was done by Klintenberg & Seely (2003). This analysis compared land degradation risk maps for Ombuga grassland, before and after 1992, the year when the water pipeline was constructed in the area. The results indicated that the Ombuga grassland and surrounding shrubland are experiencing increased risk of land degradation after introduction of this permanent water source in the area (Fig. 5). Increased land degradation risk was concluded to be mainly caused by increase in livestock pressure and negative rainfall trend (Klintenberg & Seely, 2003).

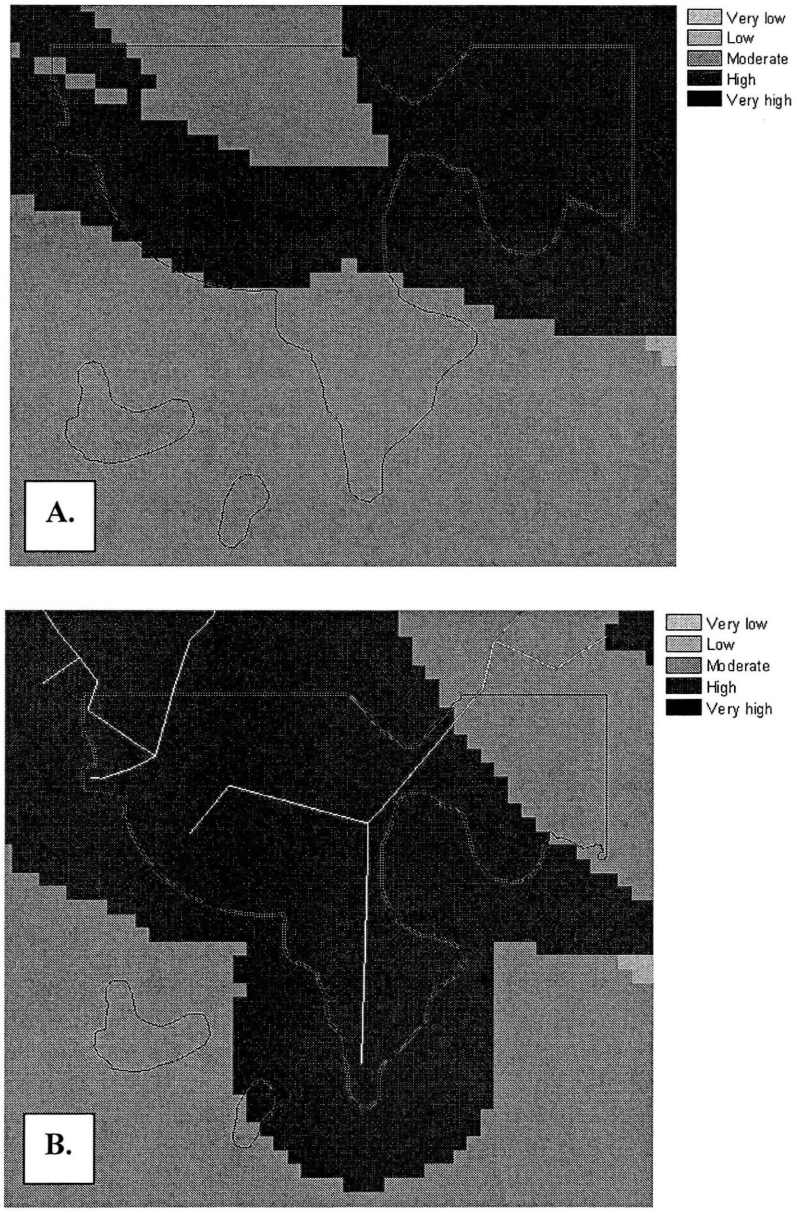

Figure 5. Map A shows the average land degradation risk for the period 1986 – 1991, and Map B shows the average for the period 1992 – 1997. Black polygon in Map A and Map B outlines the area indicated by the interviewees to be degraded and white line in Map B outlines the location of the pipeline constructed in 1991.

Analysis of rainfall records

9-year moving averages of the recorded rainfall reveal that all four rainfall-stations have recorded two wetter and two drier periods since 1931 (Fig. 6). The first dry period lasted from 1960 to 1970. The second dry period started in the later part of the 1980s and is still ongoing. Okaukuejo, Okatana and Oshikuku recorded rainfall below median during the first dry period of the 1960s while Ombalantu recorded "less" dry conditions. All four stations have recorded rainfall below median during the present dry period, starting with the 1984/85 season. The Ombalantu station has recorded the largest negative deviation from the median rainfall and Okatana the least. To establish if the rainfall during the present dry period is significantly different compared to previous records the annual rainfall during the period 1931 to 1984 was compared to annual rainfall for the period 1985 to 2000, the annual rainfall during the two dry periods recorded (1960-1968 and 1985-2000) were compared, and the annual rainfall during the last wet period (1969-1984) was compared to the present dry period. Table 3 presents the results of this analysis.

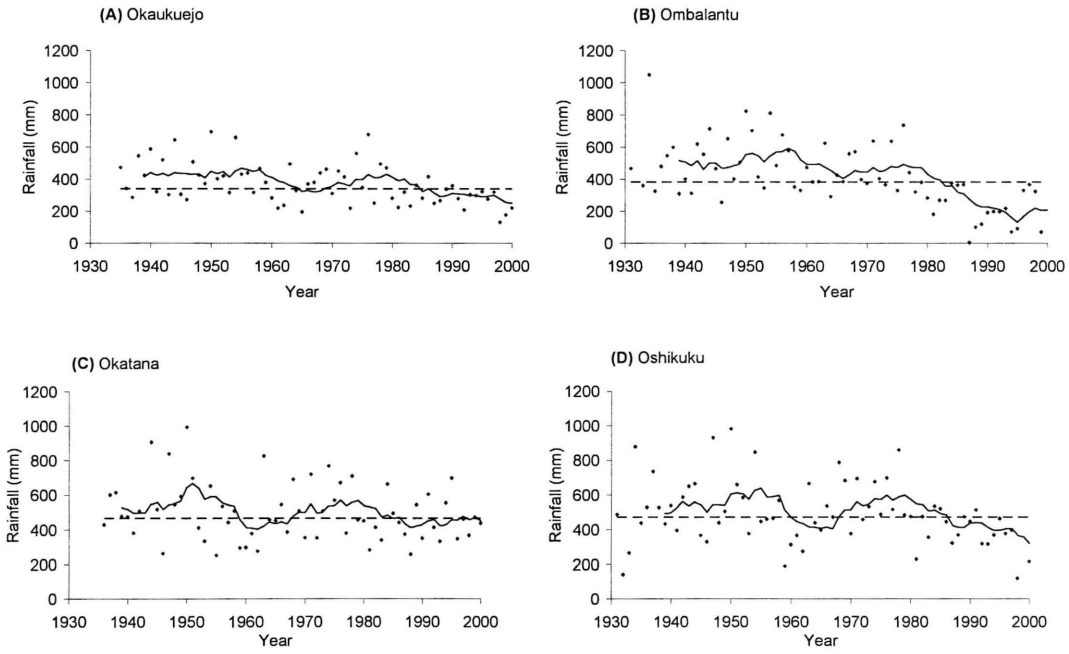

Figure 6. Annual rainfall (dots), median (dotted line) and 9-year moving average (line) recorded at the four stations for the period 1930-2000.

Table 3. *Significance test of differences between periods of lower and higher annual rainfall between 1930 and 2000, using Mann-Whitney U-test. n1 = number of samples in first group, n2 = number of samples in second group, U = calculated sample statistic N.S. = not significant.*

Station	Period	Time periods	n1	n2	U	p-level
Okaukuejo	long term vs. recent	1935-1984 vs. 1985-2000	50	16	167.5	$p < 0.01$
Ombalantu	long term vs. recent	1931-1984 vs. 1985-1999	52	15	72	$p < 0.01$
Okatana	long term vs. recent	1936-1984 vs. 1985-2000	48	16	300.5	N.S.
Oshikuku	long term vs. recent	1931-1984 vs. 1985-2000	54	14	202	$p < 0.01$
Okaukuejo	wet vs. dry	1969-1984 vs. 1985-2000	16	16	69.5	$p < 0.05$
Ombalantu	wet vs. dry	1969-1984 vs. 1985-1999	16	15	35	$p < 0.01$
Okatana	wet vs. dry	1969-1984 vs. 1985-2000	16	16	98.5	N.S.
Oshikuku	wet vs. dry	1969-1984 vs. 1985-2000	16	14	43	$p < 0.01$
Okaukuejo	dry vs. dry	1960-1968 vs. 1985-2000	9	16	51	N.S.
Ombalantu	dry vs. dry	1960-1968 vs. 1985-1999	9	15	5	$p < 0.01$
Okatana	dry vs. dry	1960-1968 vs. 1985-2000	9	16	68	N.S.
Oshikuku	dry vs. dry	1960-1968 vs. 1985-2000	9	14	51	N.S.

Discussion

In the introduction of this paper it was stated that land degradation in arid and semi arid parts of the world, often referred to as desertification, is a complex issue. According to interviewees in this study, land degradation is understood as a decrease in productivity, manifested as decreased fodder availability, changed grass species composition and increased occurrence of bare soil patches. The main causes of perceived land degradation were decreasing rainfall since the beginning of the 1990s and increasing numbers of livestock grazing in the area. This corresponds to results from the national level monitoring system, concluding that increased risk of land degradation in the Ombuga grasslands and surroundings is mainly caused by increase in livestock pressure and negative rainfall trend (Klintenberg & Seely, 2003). Iinterviewees also introduced the concept of reduced resilience, i.e. increased rainfall after a dry period results in more grass but of lower quality than previously. Nevertheless the question of long-term degradation, or desertification, occurring in the Ombuga grasslands remains unanswered. A comparison between the land degradation map drawn by the interviewees (Fig. 5), and the two maps presented in (Fig. 1) above shows some correspondence. The extent of high land degradation risk map B in Fig. 1 (after the pipeline was constructed) shows some correspondence to the map drawn by the interviewees.

A conceptual model, based on the findings from the interviews with local farmers, has been developed describing the relationships between the manifestations of land degradation identified by the interviewees, and the underlying variables leading to the perceived degradation in the study area (Fig. 7). According to the interviewees there are two major causes of the perceived land degradation in the area, i.e. decreasing rainfall and increasing livestock numbers. However, if we examine the variables in the conceptual model, which is based on the information given by the interviewees, we see that there are three fundamental factors causing the land degradation: rainfall variability, the introduction of pipelines providing permanent access to water and the slow introduction of regional councils, leaving the traditional authorities with limited control of the resources.

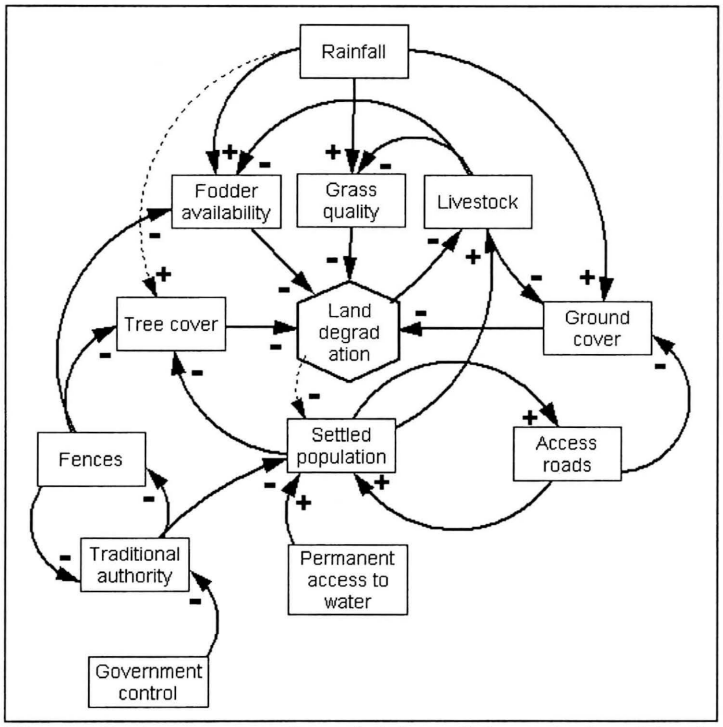

Figure 7. A conceptual model describing relationships between manifestations and causes of perceived land degradation in the study area. Thick lines indicate strong relationships between variables, while dashed lines indicate weaker relationships. Variables responding in similar directions are linked with (+) and variables responding in opposite directions are linked with (-).

The analysed rainfall data suggests a periodicity of drier and wetter conditions, similar to the southern African 18-year rainfall cycle described by (Tyson, 1986; Tyson, 1991). The results indicate that the present drier conditions are not unique and that drier periods are part of normal conditions in central northern Namibia. However, the results also show that the present dry period is longer (since 1985) compared to the drier period that occurred in the 60s, which lasted only for about eight years. The length of the present drier period could have contributed to the general decreased availability of fodder for livestock, decreased grass quality and decreasing ground cover, referred to by interviewees.

Interviewees indicated that areas most affected by land degradation are around water points, along pipelines and around dams, suggesting that perceived land degradation is related to location of water points and livestock pressure. The relationship between grazing and land degradation around permanent water sources has been shown within the study area (Langanke, 2000; Larsson, 2003) and at other locations in southern Africa (Skarpe, 1991; Moleele, 1999). The extent of areas indicated to be degraded around permanent water sources corresponds to observations made in central Namibia and Botswana (Perkins & Thomas, 1993; James et al., 1999; Ward et al., 2000). Livestock numbers were said to have increased steadily since the beginning of the 90's. This corresponds to the time of the introduction of the water pipeline, allowing permanent settlement and continuous grazing of areas that were previously only grazed seasonally.

According to the interviewees, the weakening of traditional authorities, which led to an increased number of cattle posts and settlements being established without consulting local authorities, led to increased livestock numbers and increased number of illegal fences in the area, might have contributed to perceived land degradation as large areas are being privatised leaving less open access grazing available outside the fences.

Conclusion

The findings from this study show that the interviewed farmers have identified an increased rate of land degradation in the study area by using such indicators as species

composition, rainfall and occurrence of bare ground, and that they believe the main causes of land degradation to be decreased rainfall and increased number of livestock in the area. This corresponds to results generated by the Namibian national land degradation monitoring system. Furthermore, the analysis of rainfall records (1930-2000) presented lends some support to these statements. However, it was also shown that the present period of lower rainfall is not unique and that drier periods are part of normal conditions in the area.

A conceptual model based on the information given by the interviewees indicate that the introduction of a permanent water source, i.e. a pipeline to the area and the unclear mandate of the traditional authorities, might be root causes of perceived degradation in and around the Ombuga grasslands.

At least three interviewees introduced the concept of reduced resilience, i.e. increased rainfall after a dry period results in more grass but of lower quality than previously. Nevertheless the question of long-term degradation, or desertification, occurring in the area remains unanswered. A survey of the extent of actual land degradation in the study area is the next step to further evaluate results from national level monitoring and interviews presented here cf. (Dahlberg, 2000).

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