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Perceptions and realities of land degradation in arid Otjimbingwe, Namibia

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We examined the perceptions and realities of land degradation in a communal ranching area, Otjimbingwe, in arid Namibia (in south-western Africa). It is commonly perceived that large-scale degradation of Otjimbingwe has occurred due to a mixture of improper pastoral practices and pressures induced by a high human population growth rate. We sought to determine whether the inhabitants perceived land degradation to have taken place and whether their perceptions were consistent with empirical data on environmental quality. Furthermore, we wished to determine whether these pastoralists had management strategies to help them withstand the harsh environmental conditions in which they live. All respondents in our surveys perceived that the environment had become degraded. The claimed source of this degradation, a decline in annual rainfall, is inconsistent with long-term rainfall records (there was neither change nor cyclicity in rainfall over time). There is also little evidence of a decline in plant cover and soil quality in spite of the very high stocking densities. No overall pastoral strategy exists in Otjimbingwe. Options for management are extremely limited due to a variety of external and internal pressures such as a high human population growth rate, high immigration into Otjimbingwe, restricted water availability due to dams constructed upstream, and limited movement opportunities for livestock in drought periods.

Keywords: land degradation; Namibia; livestock; ranching; communal pastoralism

Introduction

'In disputes over range degradation and stocking rate, all evidence, whether scientific or other, should be empirically validated, evaluated in relation to the ideology of its

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constructors, compared with other sources of information — local knowledge in particular — and judged according to its own merits' (Behnke & Abel, 1996).

Pastoral people are suffering considerable erosion of their lifestyles in many arid parts of Africa through long-term land degradation, increased population densities and increased competition with people requiring areas for cultivation (Behnke *et al.*, 1993; Kipuri, 1995; Scoones, 1995; Mokwunye, 1996). The communal ranching area of Otjimbingwe in arid central Namibia appears to suffer such problems. There has been a huge increase (about 500–800%) in human population density in Otjimbingwe since the 1950s. Heavy grazing is apparent, particularly in the frequent dry years. Furthermore, there has been an apparent change in the type of livestock ranched, from cattle (predominantly) to goats and some sheep. This change is associated with a change in the human population. Otjimbingwe was once almost entirely populated by Herero people, who are largely cattle ranchers (see Andersson, 1856; Vedder 1934). However, at least since the national population census of 1981, the population consists almost entirely of Herero and Damara people, who are represented in almost equal proportions (Fuller, 1993 — see Results below). The Damara people ranch mostly with goats (Paskin *et al.*, 1996). This change indicated to us that, perhaps, land degradation had occurred to such an extent that it was no longer possible to raise large grazing animals such as cattle, and that only small browsing/grazing animals such as goats could be sustained. If so, this would constitute evidence of land degradation or desertification of the area.

As an arid area (mean annual rainfall = 165·4 mm), Otjimbingwe is an extremely variable environment, with large inter-annual fluctuations in rainfall (coefficient of variation = 69·4%). Hence, it may be particularly difficult for the inhabitants to perceive land degradation, particularly if it is a slow, long-term process (Behnke & Abel 1996; Aharoni & Ward, 1997; Ward & Ngairorue, 2000). Such problems of perception are particularly acute where land degradation occurs in an environment with inherently high variability. However, recognition of land degradation is necessary in order for people to develop strategies to counteract the problems created by it.

In the light of the above, our objectives in this study were to determine whether:

(1) the change in the proportion of people of the two tribes in the Otjimbingwe population resulted in a change from cattle to goat ranching, and that such a change was necessitated by a decline in environmental quality. Such a result would be consistent with the notion that desertification was occurring;
(2) the people of Otjimbingwe perceived the area to have become degraded over time, and whether this perception matched empirical data on changes in environmental quality;
(3) there are management policies to avoid problems of reduced environmental quality;
(4) the people of Otjimbingwe considered the availability and quality of water to have declined and whether this is supported by empirical data. Such a result would also be consistent with the notion that desertification is occurring.

Brief history of Otjimbingwe

Our goal in this article is to describe perceptions and realities of land degradation in Otjimbingwe today, with special emphasis on the effects of the human population on the local environment. In order to describe the changes that have occurred in the environment and human perceptions of changes, we need first to establish the historical effects of humans on the environment of Otjimbingwe. Thus, the following accounts deal with the history of Otjimbingwe, with emphasis on those events that may have affected the quality of the environment for the people living there today.

Hereros

According to their oral history, about 80 Herero people with some 500–600 head of cattle settled near Otjimbingwe by 1695 (A. Kaputu, the premier oral historian of the Herero people, pers. comm.) as a result of drought in northern Namibia. Although the Hereros were largely cattle ranchers (Lau, 1989), they owned a few sheep and goats (Guedes & Reiner, 1993). By 1850, an early European trader, Charles John Andersson, noted the presence of some 200 Hereros in Otjimbingwe (Lau, 1989). The Herero population of Otjimbingwe enlarged in 1863 (to 400–500 people; Lau, 1989) when the Herero chief Maharero arrived in Otjimbingwe from Okahandja to seek protection provided by the missionaries and European traders from the raids of another major Namibian tribe, the Nama (Pool, 1991).

The Herero presence at Otjimbingwe was not entirely settled. In 1868, Maharero moved back to Okahandja because of the drought in Otjimbingwe. From the point-of-view of this article's objectives, it is clear that the presence of the European traders and missionaries created an impetus for the native people to move into the area. This resulted in large numbers of people, and their herds, being concentrated there for periods that varied considerably in time. Additionally, it is clear that the numbers of people and livestock were limited by drought even at a time when their numbers were far less than they are today (see below).

European presence at Otjimbingwe

The first European presence at Otjimbingwe was the Rhenish mission, which started in 1849 (Andersson 1856; Guedes & Reiner, 1993). The first European trading in Otjimbingwe developed after C.J. Andersson set up his trading empire there in 1859. Records exist of 1400–4000 cattle being kept by Andersson and other European traders at Otjimbingwe at different times before being sent to the Cape (South Africa) (Lau, 1989). Hence, large stock numbers are not a recent phenomenon at Otjimbingwe, and could be expected to have contributed to land degradation.

In 1884, South West Africa (now known as Namibia) was annexed by Germany. In 1902, a German commission decided to establish the Otjimbingwe reserve, which covered 130 000 km^2. The German governor Leutwein had the following to say in 1902 on Otjimbingwe: 'Owing to its situation, the area selected for the proposed reserve is less suited for settlement by Whites' (Mossolow, 1993). Thus, the German colonial government created the reserve not out of concern for the Herero occupants but rather due to its apparent lack of suitability for White (European) farmers. Contrastingly, other proposals for reserves owned by Hereros in more mesic areas of the country were squashed because they held promise for White farmers. Thus, from an agricultural point-of-view, the poor environmental conditions in Otjimbingwe were already recognized by Europeans in 1902.

Damaras

The Damara people, who were subjugated by the Nama people in the early 18th century, came to the Otjimbingwe region some time after 1830. The Damara people had no stock, and occupied the mountains in the vicinity (Fig. 1). As an enslaved people of the Namas, the Damaras had few possessions.

In 1850, Andersson recorded no Damaras at Otjimbingwe. His first mention of Damaras in the region is at Onanis, in the hills some 60 km south-west of Otjimbingwe. He recorded them as possessing no livestock and living off wild fruit and roots. Their diet at and prior to this time is elsewhere described as consisting of roots and

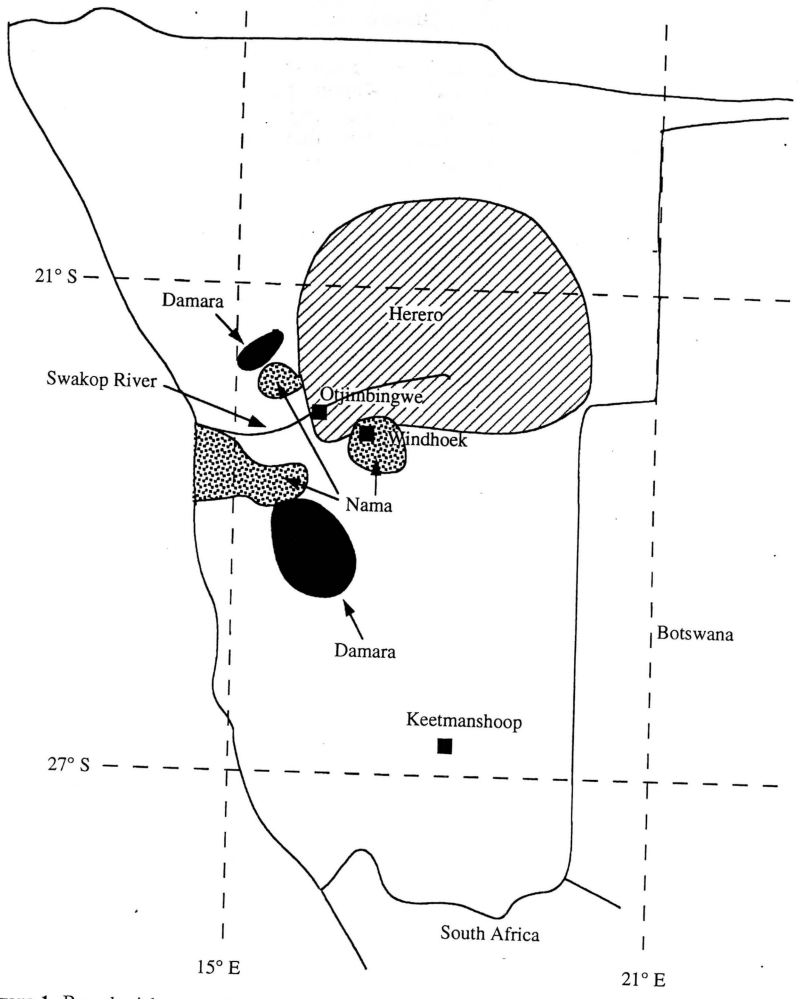

Figure 1. Precolonial occupation of central Namibia (from early 1800s to 1880s—after Van der Merwe, 1985). Areas in black were occupied by Damara people, hatched = Herero areas, dotted areas = occupied by Namas. Note that Nama people occupied areas to the south of this map as well as those indicated.

'uintjies' (a sedge, *Cyperus* sp.), the gum of thorn trees (Steyn & du Pisani, 1984/85) and mice, lizards, roots and leaves (Alexander, 1838). Subsequent to their release from slavery by the Namas, Damara presence in Otjimbingwe in the early years was almost entirely in association with the Europeans in the town, either as domestic workers or workers in various aspects of European trading. The Damaras were later encouraged by the missionaries to farm with crops in the Swakop river at Otjimbingwe. Some Damaras

later acquired goats, as indicated by Andersson in 1864 (Lau, 1989). Andersson did not mention them possessing any cattle (see also Palgrave, 1877). According to Vedder (1923), the Damaras obtained cattle 'recently'. Other sources suggest that the Damaras were given, bartered or stole small stock (see also Hahn, 1877; Büttner, 1879; Gürich, 1891; Schinz, 1891; Von Francois, 1895; Irle, 1906; Range, 1914). Thus, in the light of our objectives in this article, it is clear that the Hereros were the first people in Otjimbingwe, and that they were stock (mostly cattle) ranchers, while the Damaras arrived far later, were not usually stock ranchers, and were mostly associated with trade activities with the Europeans.

Otjimbingwe after World War I

After the German–Herero war (1904–1907), political pressure from European farmers' unions caused a long period of erosion of the land area in the original 130,000 km^2 Otjimbingwe reserve granted to the Hereros by the German colonial government in 1902. In 1915, South African troops overthrew the Germans in what was then called South West Africa. Under South African control, and especially during the apartheid era in Namibia (1948–1990), the area of European-owned farms increased by 346% between 1913 and 1962 (Fuller, 1993). This pressure on the land resulted in very high stocking densities in the small areas that the Hereros were restricted to. In 1921, for example, the ranch Otjimbingwe Nord (13,000 ha—a subset of the current Otjimbingwe) was a largely Herero-controlled communal ranch with 10,000 small stock and 800 large stock (Fuller, 1993). This is equivalent to a stocking density of 6·8 ha per Large Stock Unit, where one Large Stock Unit (LSU) is equivalent to one 450 kg cow or six sheep or goats (Meissner *et al.*, 1983). The recommended stocking density for Otjimbingwe is 27·6 ha LSU^{-1} (Fuller, 1993). Therefore, the stocking density was four times higher than the recommended density. These high stocking densities became particularly problematic because the increased land area of commercial farms prevented people in Otjimbingwe from moving out in drought years in order to find better grazing further north, as they traditionally had done. As black people, the residents of Otjimbingwe did not have the option to purchase land elsewhere, such as in commercial areas, particularly from the time of the South African occupation in 1915 until independence in 1990.

Otjimbingwe was established in its present form in 1923. The Otjimbingwe reserve comprised 83,053 ha (Fuller, 1993) and increased to 92,000 ha in 1929. Although most members of the population were involved in stock ranching (it is too dry to grow crops outside of the riverbeds), much crop farming was conducted in the ephemeral Swakop river that runs through Otjimbingwe. Crop farming was a relatively successful enterprise in the first half of the 20th century; a mean wheat harvest of 24 tons year^{-1} (area farmed not recorded) was recorded (Fuller, 1993). When added to income from pastoral activities, this harvest provided the African community with economic independence (Fuller, 1993).

Until the mid-1970s, annual floods from the Swakop river provided the residents of Otjimbingwe with necessary water for irrigation. Very little cultivation occurs today, primarily due to the construction of the Swakoppoort Dam about 50 km upstream from Otjimbingwe, and perhaps secondarily to the building of the Von Bach Dam in the 1960s at Okahandja about 100 km upstream from Otjimbingwe. These dams were built with the purpose of providing urban areas, especially Windhoek (Namibia's capital city) with water. It was hoped at the time of their construction that these dams would also facilitate controlled releases of floodwater downstream. However, these controlled releases of water have seldom been forthcoming, resulting in water becoming less available to the residents of Otjimbingwe. Indeed, the river downstream of these dams has flooded only twice since the building of the dams (Fig. 2—data from Department of

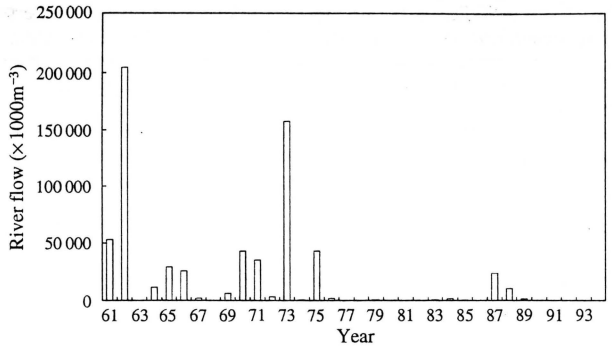

Figure 2. Changes in water flow in the Swakop river at Westfalenhof weir. This ranch is immediately upstream of Otjimbingwe. Note that the river has only flowed here (downstream of the Swakkoppoort Dam) twice since the dam was built in 1977. Data from the Namibian Department of Water Affairs.

Water Affairs of the Namibian Ministry of Agriculture, Water and Rural Development).

The Otjimbingwe human population increased exponentially from about 1954, with a growth rate very similar to the national average (Fig. 3). By the time of the 1981 national population census, 2500 people were recorded as living in Otjimbingwe (Fuller, 1993). Today, some 5000–6000 people live in the Otjimbingwe communal area (Otjimbingwe town commissar, pers. comm.), although there are unconfirmed reports of as

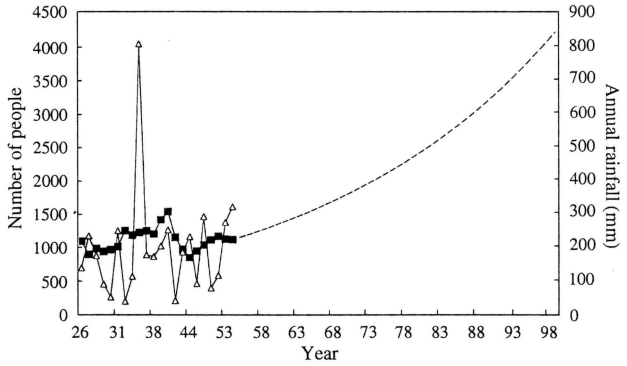

Figure 3. Growth of the Otjimbingwe human population and annual rainfall from 1926 to 1954. Population data from 1926 to 1954 are from population censuses (Fuller, 1993). From 1954 to 1997, a simple extrapolation using the national average growth rate of 3·0% was used. This extrapolation matched the censused population size in Otjimbingwe in 1981 remarkably well (extrapolation = 2478 people; actual population = 2500 people). However, the population has since grown to 5000–6000 people, which is 25–50% higher than that predicted by the extrapolation (= 3976 people in 1997) at the national average growth rate. The difference in population is probably accounted for by immigration into Otjimbingwe. —■— Censused population; ---- estimated populations; —△— annual rainfall from 1924 until 1954.

many as 8000 people. Between 800–2000 of these people live in the town, and the rest live in the surrounding ranching area. The large increase in the number of people in Otjimbingwe between 1981 and 1997 is largely due to immigration from local commercial farms and even further afield.

The number of ranching families per unit of ranching area is much greater today than it was in the past. For example, in 1952, 224 families had 406 ha per family to graze their stock (Fuller, 1993), while in 1996, 472 families had 248 ha per family for their stock. In 1927, 952 people on Otjimbingwe had 3665 large stock and 16,593 small stock (= 5549 LSU), with 16·58 ha LSU^{-1} (Fuller, 1993). In 1952, 1164 people had 7001 large stock and 12,977 small stock (= 8443 LSU), with 10·90 ha LSU^{-1} (Fuller, 1993). Today, there are 6200 LSU on Otjimbingwe (= 17·8 ha LSU^{-1}) (Namibian Directorate of Veterinary Services, unpubl. report). It is therefore clear that Otjimbingwe has long had, and still has, a large human population and high livestock population densities.

Methods

Livestock surveys

We used a variety of sources to obtain data on the numbers of livestock in Otjimbingwe at various times, including Fuller (1993), semi-annual surveys by the Namibian Directorate of Veterinary Services, and direct surveys (see below) of ranchers in the Otjimbingwe reserve.

Water quantity and quality

We used water quality and quantity data collected by the Department of Water Affairs of the Namibian Ministry of Agriculture, Water and Rural Development at boreholes used by the people of Otjimbingwe between 1989–1996.

Sociological study

We conducted two sociological surveys, and in both surveys mostly elderly, long-term residents were selected. The reason for this choice of interviewees was to get reliable long-term information from them concerning perceived changes in the ecology of the area. In order to ensure that the answers we received were reliable, we selected people who had spent their whole lives in the area and were dependent on the land for their livelihood. All respondents were selected randomly and interviewed independently. Only native OtjiHerero-speaking and Nama/Damara-speaking interviewers were used in the surveys to remove possible biased responses to outsiders.

Survey 1: We interviewed 28 residents of the town in December 1996. The goal of this first survey was to determine the perceptions of the residents of possible land degradation. All respondents were asked the same questions.

Survey 2: In February 1997, we interviewed 30 residents of Otjimbingwe. In this second interview series, we were interested in the reasons for migrations and movements of people into and away from Otjimbingwe. All respondents were asked the same questions.

Grass cover and soil parameters

In an earlier study (Ward *et al.*, 1998), we compared the plant diversity and soil quality in the communal ranching areas of Otjimbingwe and in the surrounding commercial

ranches where stocking densities are 10-fold lower. As the commercial ranches have only been in used in this century, this comparison relates to short- to medium-term effects of grazing. Here we supplement these data with an attempt to measure long-term degradation, i.e. we compare data from three watering points that have been in use by stock since the time of Andersson (1850s–1860s) and compare them to three watering points that have only come into use in the last 6–10 years. Specifically, we measured mean grass height and density using a point-frequency frame along a 1000 m gradient leading away from each watering point (for further details, see Ward *et al.*, 1998). These measurements were made in March 1998 at the end of the wet season. Grass measurements are made at this time because dry season measurements may indicate current and not long-term effects of heavy grazing, while recovery after the wet season indicates the availability of soil nutrients to sustain grass biomass. If the land is not degraded, there will be a 'sacrifice' zone immediately around the water where all vegetation is eaten or trampled (= piosphere) and then an increase in grass biomass with increasing distance from water (Pickup & Chewings, 1994). If land degradation has occurred, there will be no increase in grass biomass with increasing distance from the watering point because all areas will be similarly damaged.

In addition to the grass measurements, we also recorded the water-holding capacity of the soil, a reliable measure of soil quality in an arid area and one that is strongly positively correlated with two other important measures of soil quality, organic carbon and soil nitrogen (Ward *et al.*, 1998). We also used a bioassay, which provides an overall measure of soil quality. Radishes (*Raphanus sativus* L.) were used as the bioassay because they are capable of growing in a wide range of soil types and thus differences in biomass will not be due to preferences for a specific soil type (Ward *et al.*, 1998).

Results

Livestock survey

Of 472 stock owners in Otjimbingwe in 1995, 48·5% (229) were Damara ranchers and 48% (227) were Hereros, with 2% Owambo and 1·5% Nama ranchers. Women constituted 33% of all livestock owners ($n = 156$). There was no significant difference between men and women in the total number of livestock owned (Analysis of Variance (ANOVA): $F = 0{\cdot}793$, $p = 0{\cdot}374$, error df. = 406), but there was a significant difference between Hereros (mean $\pm$ S.E. = $72{\cdot}84 \pm 5{\cdot}52$ animals) and Damaras ($52{\cdot}96 \pm 4{\cdot}79$ animals) (ANOVA: $F = 7{\cdot}40$, $p = 0{\cdot}007$, error df. = 406). There was no significant interaction effect between gender and tribal affiliation (ANOVA: $F = 0{\cdot}41$, $p = 0{\cdot}52$, error df. = 406). The number of small stock units owned did not differ significantly between men and women (ANOVA: $F = 0{\cdot}51$, $p = 0{\cdot}48$, error df. = 406), tribal affiliation (ANOVA: $F = 2{\cdot}07$, $p = 0{\cdot}15$, error df. = 406), or interaction between these two factors (ANOVA: $F = 0{\cdot}46$, $p = 0{\cdot}50$, error df. = 406).

There was a highly significant difference between Damaras and Hereros (ANOVA: $F = 39{\cdot}61$, $p < 0{\cdot}0001$, error df. = 406) in the number of cattle owned. Cattle comprise only $6{\cdot}6 \pm 2{\cdot}0\%$ of the Damaras' stock, while they comprise $26{\cdot}0 \pm 2{\cdot}2\%$ of the Hereros' stock. There was no significant difference between men and women in the number of cattle owned (ANOVA: $F = 0{\cdot}27$, $p = 0{\cdot}61$, error df. = 406), or interaction between these two factors (ANOVA: $F = 0{\cdot}15$, $p = 0{\cdot}70$, error df. = 406). Thus, the difference in total number of livestock between Hereros and Damaras is due largely to a difference in the number of cattle owned.

We found a significant positive correlation between the number of cattle owned by Hereros and the number of small stock ($r = 0{\cdot}47$: ANOVA: $F = 56{\cdot}167$, $p < 0{\cdot}0001$, error df. = 203). This result is also true of the Damaras, although the correlation is

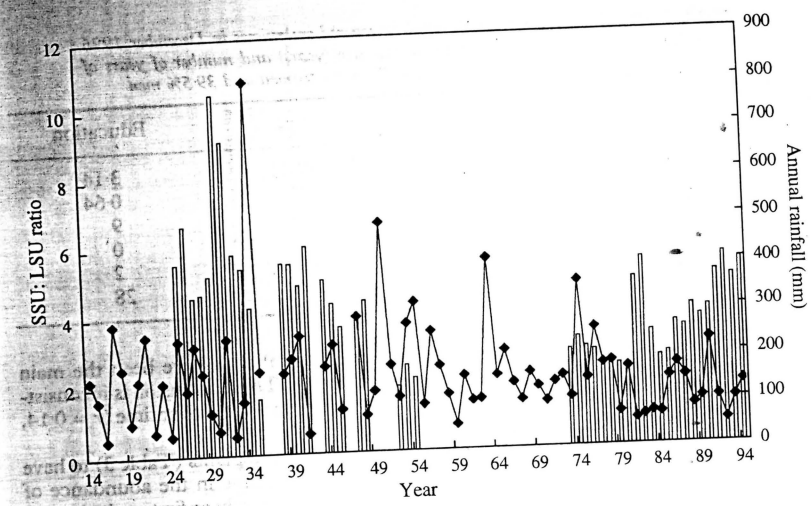

Figure 4. Ratio of small stock to large stock at Otjimbingwe from 1925 to 1954, and from 1973 to 1994. Annual rainfall from 1914–1994. Note that there was very little change in the SSU:LSU ratio in spite of large changes in rainfall among years. ▭ SSU:LSU ratio; —◆— rainfall.

lower ($r = 0{\cdot}16$; ANOVA: $F = 5{\cdot}208$, $p = 0{\cdot}024$, error df. = 205). These results indicate that wealthier people own both more small and large stock and that the type of stock that a rancher has is more likely due to wealth than a specific stocking strategy. This conclusion is supported by the observation that there is no evidence of an overall change in the ratio of small stock to large stock over time (Fig. 4), in spite of large fluctuations in rainfall and, hence, in grass availability. There was no correlation between the large stock to small stock ratio and rainfall ($r = 0{\cdot}014$, $F = 0{\cdot}528$, $p = 0{\cdot}472$, error df. = 37), or any significant 1- or 2-year lag effect ($p > 0{\cdot}667$). That is, an adaptive change in stock type from cattle (which require lots of forage) to goats (which require less forage to survive and can eat bushes as well as grass) has not occurred in Otjimbingwe. We do note, however, that there have occasionally been tendencies to stock a greater proportion of cattle after years of good rainfall (e.g. 1934–1935; Fig. 4).

Sociological study: survey 1

Respondents

The percentage of literate people in our survey at Otjimbingwe (50%) was significantly lower than the national value determined in the 1991 Namibian population census (77%) ($\chi^2 = 11{\cdot}1$, $p < 0{\cdot}001$, df. = 1) (Table 1). However, the percentage of all school attendees who had attended secondary school (28·6%) did not differ significantly from the national value (50%) ($\chi^2 = 2{\cdot}6$, $p > 0{\cdot}1$, df. = 1), although this may be due to the small sample size in our census. All respondents owned a large number of livestock (Table 2) and hence were aware of grazing conditions in the area.

Changes over the years

With regard to changes in conditions over the years, all respondents considered that distance to good grazing and time to collect firewood had increased over time. All

Table 1. *Details of respondents in semi-structured interviews in December 1996 regarding years of residence in Otjimbingwe, age (years) and number of years of education. Of the 28 respondents, 60·7% were women and 39·5% men*

	Residence	Age	Education
Mean	36·54	57·43	3·14
S.E.	3·77	2·74	0·64
Maximum	80	80	9
Minimum	5	30	0
Median	33	56	2
n	28	28	28

respondents considered a decline in the mean annual rainfall to have been the main cause for the decline in grazing conditions in Otjimbingwe. This conclusion is inconsistent with the data (Fig. 4). There was no significant change in rainfall over time ($r = 0{\cdot}14$, ANOVA: $F = 1{\cdot}547$, $p = 0{\cdot}217$, error df. = 76).

All respondents considered the numbers of wild animals and plants (Table 3) to have declined over time. All respondents particularly noted a decline in the abundance of 'uintjies' (*Cyperus* sp.), a species whose bulb is either eaten directly or first cooked on an open fire and eaten without further preparation.

Only six respondents (21·4%) changed their livestock over the years from cattle to goats (which require less forage for survival, and eat bushes as well as grass), while 20 (71·4%) had made no changes. A further two respondents (7·2%) indicated that they started ranching with cattle but they died because of the drought. Thus, these data support the results of the livestock surveys that show that few ranchers adaptively change their stocking strategies in response to changes in forage availability caused by drought.

Water

A common consequence of over-use of water resources in arid areas is an increase in the salinity of the water. Water quality was considered by one of the 28 respondents to have become more salty over time, two residents said it had become less salty, while 18 (64·3%) said that water quality had stayed the same. Of the respondents, a further seven (25%) said that the water quality depends on the area of the town (presumably due to the use of different aquifers); people living further downstream were more likely to complain about the saltiness of the water. One respondent noted that he drew water from the waterpoint in Otjimbingwe town, rather than near his homestead on the Omusema river, because the former waterpoint always had sweeter water. Thus, overall, a highly significant proportion of respondents did not consider water quality to have changed with time ($\chi^2 = 17{\cdot}29$, $p < 0{\cdot}001$, df. = 1). These responses are consistent with data obtained from the Department of Water Affairs of the Namibian Ministry of Agriculture, Water and Rural Development for boreholes at Otjimbingwe. Over the

Table 2. *Number of livestock of respondents. All respondents owned some animals*

	Cattle	Goats	Sheep	Donkeys	Chickens	Horses	Pigs
Mean	22·86	53·4	21·2	3·86	8·3	2·75	4
S.E.	5·55	17·03	8·35	0·44	1·65	0·48	—
Max.	70	300	50	6	15	4	4
Min.	2	6	7	1	3	2	0
Total	320	1068	76	84	50	11	4

Table 3. *The respondents indicated that the edible plants listed below have declined in abundance. The availability of the fruits listed fluctuates considerably, and may still be abundant during a good rainy season. A = Afrikaans, E = English (additional data obtained from Steyn & du Pisani, 1984[5]; Van den Eynden* et al., *1992)*

Nama/Damara name	Scientific name	Common name	Comments
//ain	*Grewia tenas*	Rooi bessie (A)	Raw fruits are eaten
/hunin	*Boscia albitrunca*	Caper bush (E), Witgat, Witsstandboom (A)	Raw fruits are eaten
Hairan	*Acacia erubescens*; A *reficiens*; *A. mellifera*	Gum (E), Gom (A)	Edible gum is eaten
!hanan	*Cyperus* spp.	Uintjies (A)	Nutlike tubers are eaten
≠ eron	*Ximenia americana*	Sour plum (E), Kleinsuurpruim (A)	Raw fruits are eaten
Dadel (A)	*Phoenix dactylifera*	Date palms (E), Dadel (A)	Fruits are eaten fresh or dried
Sapiben	Undetermined, possibly *Grewia* sp.		Raw fruits are eaten

period 1989–1996, at five boreholes in the communal area, there was an improvement (rather than a decline) in water quality; there was a negative correlation between the Total Dissolved Solids (measured in mg ml^{-1}) and time ($r = -0{\cdot}87$; ANOVA: $F = 12{\cdot}42$, $p = 0{\cdot}024$). Furthermore, consistent with the respondents' claims that there were more differences among boreholes than changes over time at any borehole, we found that the coefficient of variation among boreholes (CV = 0·68) was far higher than the mean CV within boreholes over time (mean CV ± S.E. = 0·24 ± 0·07). Contrary to the results on water quality, there was a change in water quantity over time. Mean water yield declined significantly at six boreholes from 1986–1997 ($r = -0{\cdot}92$; ANOVA: $F = 58{\cdot}215$, $p < 0{\cdot}001$, error df. = 10)(Table 4).

Since independence from South Africa in 1990, most respondents (16 out of 28—57·1%) have relied on government drought relief payments during drought conditions. Lesser proportions of respondents either move to better grazing areas (3 out of 28—10·7%), leave to work in urban areas (5 out of 28—17·9%), or rent or receive (free-of-charge) grazing lands from commercial ranchers (1 out of 28). The low percentage of people moving out of Otjimbingwe in response to drought is congruent with data from Fuller (1993) which show that even in the first half of the century, when there were more areas unoccupied by commercial ranchland, the population did not respond to rainfall fluctuations by emigration (Fig. 3). There was no significant correlation between human population size and rainfall ($r = 0{\cdot}012$, ANOVA: $F = 0{\cdot}303$, $p = 0{\cdot}587$, error df. = 24), nor any significant 1- or 2-year lag effect ($p > 0{\cdot}311$).

During drought, 17 (60·7%) of the 28 respondents sold their animals, 10 (35·7%) said their animals simply died, while one rancher moved to better areas with his/her animals. With regard to whether they keep extra animals for outsiders during good rainy seasons, 22 (78·6%) said yes, while 6 (21·4%) said no, indicating that the animals maintain a high grazing pressure even in good years.

All of the respondents indicated that the headman and/or community does not make any stocking decisions and that stocking decisions are an individual matter. This response is consistent with data from Fuller (1993), and Namibian Directorate of Veterinary Services semi-annual stock reports that show that there is no correlation between the number of Large Stock Units in Otjimbingwe and rainfall ($r = 0{\cdot}004$, ANOVA: $F = 0{\cdot}163$, $p = 0{\cdot}688$, error df. = 37), or any significant 1- or 2-year lag effect ($p > 0{\cdot}374$—Fig. 5), i.e. animal numbers are not actively managed in response to environmental conditions. This result contrasts with the general observation that Hereros move their cattle depending on environmental conditions (see Results of second survey and Brief History of Otjimbingwe above), and is inconsistent with the reports of some researchers that communal ranchers frequently show a high degree of coordinated management of pastoral resources (e.g. Ellis & Swift, 1988; Werner, 1994).

Table 4. *Mean changes in water yield at six Otjimbingwe boreholes over time. Means ± S.E. are presented*

Year	Water Yield, m^3 h^{-1}
1986	10·43 ± 2·59
1987	9·99 ± 2·24
1988	9·68 ± 2·45
1989	9·00 ± 2·00
1990	8·69 ± 1·85
1991	6·66 ± 0·99
1992	7·99 ± 1·47
1993	7·94 ± 1·77
1994	5·86 ± 1·05
1995	5·60 ± 1·31
1996	6·06 ± 0·94
1997	6·23 ± 1·59

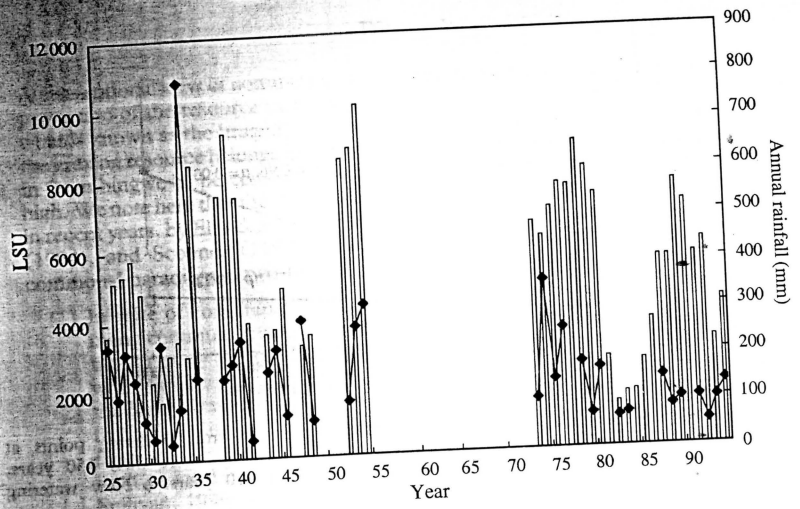

Figure 5. Otjimbingwe livestock population size (in LSU) and annual rainfall from 1925 to 1954, and from 1973 to 1994. ▭ LSU; —◆— rainfall.

Sociological study: survey 2

All of the respondents indicated that the Hereros had more cattle than the Damaras. Regarding the perceived reduction in the numbers of Hereros in Otjimbingwe, 73% of the respondents said that this was not true, while 27% said that this was indeed the case ($\chi^2 = 6{\cdot}53$, $p < 0{\cdot}025$, df. = 1). There was a non-significant difference between the number of respondents that claimed that the Hereros left because of drought and normally return after rain (19 out of 30 respondents) and those that said that the Hereros did not move as a result of drought ($\chi^2 = 2{\cdot}13$, $p < 0{\cdot}20$, df. = 1). These Herero people live a form of nomadic life, either renting neighbouring pastures for grazing or keeping their cattle on the vegetated road verges between commercial ranch fencelines during harsh drought periods. Two respondents said that some Hereros left Otjimbingwe during the war of liberation from South Africa, although the remainder said that this was not the case ($\chi^2 = 19{\cdot}20$, $p < 0{\cdot}0005$, df. = 1). These people have settled in towns further north, such as Omaruru and Okahandja. The Damara headman claimed that many young Herero men had left to seek work in larger towns. Thus, in sum, the respondents considered Herero migrations to be largely temporary movements, although opinion was divided as to whether these movements were dependent on rainfall.

No date could be given by either the Herero or Damara respondents as to the time of arrival of the Damara people in Otjimbingwe. Herero respondents pointed to the absence of graves of earlier generations of Damaras as an indicator that they had not been present in Otjimbingwe for a long time. The Herero headman considered that the first Damaras arrived in Otjimbingwe during the German–Herero war from 1904–1907, and started working as poorly-paid labourers for the Hereros. An additional respondent

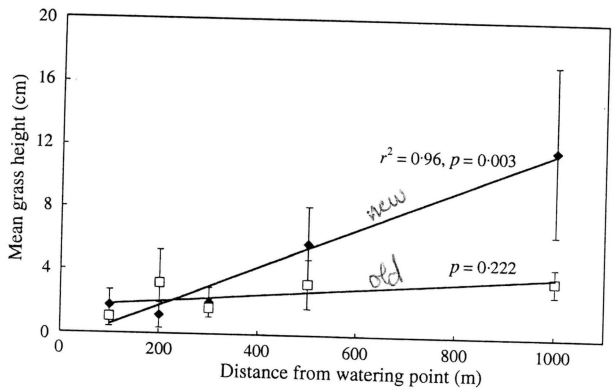

Figure 6. Mean ± S.E. grass height with increasing distance from watering points at Otjimbingwe. Old watering points are those in sustained use for more than 150 years, while new watering points have been in use for less than 10 years. ◆ New watering points; □ old watering points.

mentioned remembering that the Damaras worked in the creamery in Otjimbingwe town in the 1920s.

All Damaras claimed that they arrived in Otjimbingwe because of the availability of water and grazing. There was also work for the Damaras to do, for the wealthier Hereros and for the White traders (who are no longer present). Indeed, today, the Damaras are largely concentrated in and around the single town on the reserve, while the Hereros mostly ranch in the surrounding areas.

No Damara respondents gave a clear answer as to why they did not come to Otjimbingwe earlier, although some mentioned that they thought that their ancestors did not come to the area because there was sufficient wild food to sustain themselves elsewhere. All Damara respondents agreed that Otjimbingwe was a better place to live in than the areas that they had previously occupied.

Grass cover and soil parameters

There was a significant positive correlation between mean grass height and distance from the watering point for the new watering points ($r = 0{\cdot}98$, ANOVA: $F = 13{\cdot}123$, $p = 0{\cdot}003$, error df. = 13). There was no significant correlation between mean grass height and distance from the watering point for the old watering points (ANOVA: $F = 1{\cdot}645$, $p = 0{\cdot}222$, error df. = 13—Fig. 6). Mean grass height was significantly higher at new ($4{\cdot}487 \pm 0{\cdot}623$ cm) than at old watering points ($2{\cdot}507 \pm 0{\cdot}338$ cm) (Nested ANOVA (sites nested within old *vs.* new): $F = 7{\cdot}894$, $p = 0{\cdot}005$, error df. = 294). These results indicate that the older watering points are degraded relative to the new points.

Inconsistent with the data on grass height, there was no significant difference in soil water-holding capacity between old ($11{\cdot}44 \pm 0{\cdot}688\%$) and new ($11{\cdot}28 \pm 0{\cdot}731\%$) watering points ($t = 0{\cdot}157$, $p = 0{\cdot}876$, df. = 28). Similarly, there was no significant difference in the total biomass of radish plants produced in our bioassay between old ($1{\cdot}747 \pm 0{\cdot}098$ g) and new ($1{\cdot}618 \pm 0{\cdot}086$ g) watering points ($t = 0{\cdot}989$, $p = 0{\cdot}331$, df. = 28).

Discussion

A conventional view of communal pastoralism is that there is little or no management or protection of the resource being used. This lack of resource management may lead to what is known as the 'tragedy of the commons' (*sensu* Hardin, 1968). That is, because the grazing resource belongs to nobody, nobody cares for it. Should the grazing resource in Otjimbingwe be perceived in such a light, the potential for land degradation may be high. We note here that the 'tragedy of the commons' concept has been heavily criticized in recent years, by Ellis & Swift (1988), Archer *et al.* (1989), Shackleton (1993), Werner (1994), and Scoones (1995), among others. The criticism of the 'tragedy of the commons' paradigm is two-fold:

(1) in spite of communal ownership and lack of fencing of separate grazing areas, many communal ranches have a high degree of management by local communities. In many communal areas, tribal leaders and/or community groups decide on who may graze where and how long they may use the resource for;
(2) the high inherent variability of many arid African pastoral ecosystems is driven by the availability of rainfall. Consequently, the effect of high stocking rates is frequently rather small in comparison with the effects of abiotic variables such as local rainfall (e.g. Ellis & Swift, 1988; Tapson, 1993; Scoones, 1995; Sullivan, 1996; Ward, in press). Overgrazing, in this view, is therefore usually a short-term problem that is frequently rectified by large rainfalls in some years.

Management of grazing areas and control thereof by the local headmen or community groups does not occur in Otjimbingwe, *contra* observations in other African communal areas (see e.g. Ellis & Swift, 1988). Thus, Otjimbingwe does have the potential for the 'tragedy of the commons' to occur. In spite of this, and extremely high stocking densities, we have found no long-term degradation of vegetation or soil resources (Ward *et al.*, 1998; Ward *et al.*, in press). We found that plant species cover, richness and diversity as well as grass availability after a rainy season is similar to that on surrounding commercial ranches, which have approximately tenfold lower stocking densities (Ward *et al.*, 1998, Ward *et al.*, in press). Similarly, we found no significant difference in soil nitrogen, phosphorus, organic carbon and water-holding capacity between Otjimbingwe and the commercial ranches which have been in use in this century only (Ward *et al.*, 1998). The only evidence we have of land degradation is from the decline in grass production at Otjimbingwe watering points used for over 150 years relative to the new watering points used for less than 10 years (Fig. 6). These differences were not supported by the soil quality data at these points. Furthermore, if there had been serious land degradation we would expect to see a decline in stock numbers over time as a consequence of insufficient soil resources to maintain forage resources (Dean & MacDonald, 1994). However, there has been no noticeable decline in stock numbers (Fig. 5), substantiating our claim that no serious land degradation has occurred. Our findings are consistent with those of Ward & Ngairorue (2000) who showed that heavy grazing does not usually cause degradation in Namibia's arid environments in the short- to medium-term. Heavy grazing may only cause land degradation if it is sustained in the long term, say in excess of 80–100 years (see also Wiegand & Milton, 1996). These findings are supported by those of Rohde (1997) who compared matched photographs taken in the vicinity of the town of Otjimbingwe in the period 1904–1914 with those taken in 1995. There have been both increases and decreases in the vegetation over time. Rohde (1997) shows that the Swakop river bank and adjacent floodplain north of the river are inhabited by more *Acacia tortilis* and *Faidherbia albida* trees than they were in the past, while an area near the Swakop river now has fewer trees and shrubs than it did in the past. The increased *Acacia*/*Faidherbia* tree density in the vicinity of the river may be due to rare mass recruitment of these trees after the large floods in the period between the photographs (esp. in 1934) and probably has little to do with human

activities (Ward & Rohner, 1997). It is clear from the photographs that the piosphere (sacrifice zone) around the watering points near the town have enlarged over this century (to about 0·5 km radius) and that many trees have been chopped down in the area north of the town. Thus, the perceived decline in environmental quality and the increased distances that the respondents indicated that they have to walk to obtain firewood and grazing may be related to these changes in the piosphere only. We note that the photographs were taken in the vicinity of the town where stocking densities are largest and defoliation (e.g. for firewood, fencing and house-building) is heaviest. Hence, these are the areas with the greatest negative impact of human activity and yet even they are not particularly heavily affected. Indeed, Rohde (1997) concluded that 'the photographic evidence would again seem to contradict the received wisdom that over-utilization occasioned by sedentarization and so-called 'open access' tenure regimes leads to pronounced irreversible land degradation'. These results point to the extreme resilience of the Otjimbingwe environment and the over-riding importance of rainfall, and not stocking densities, on environmental quality (see also Ward, in press).

Changes in ranching practices at Otjimbingwe over time

Our initial observation that there had been a change in livestock practices in Otjimbingwe over time is not strictly correct. While it is true that the Damara population (who mostly raise goats) has increased over time, it is not correct that the cattle-raising Hereros have left, and nor is it true that the Hereros are no longer able to sustain their cattle there. Rather, it appears that type of livestock is associated with wealth (cattle are more expensive than goats) and that both Damaras and Hereros own cattle and small stock. Wealthier people are likely to own more cattle and more small stock. Hereros are wealthier than Damaras (on average, they have 20 more animals per person — see Results) and, hence, have more cattle. Similarly, few ranchers have an adaptive strategy of changing either the type or number of stock in response to changes in rainfall, although several ranchers did sell their animals in droughts. Thus, the proportion of goats has increased over time mostly because the numbers of Damaras has increased (presumably due to political factors unrelated to ranching), i.e. not because of a change in management strategy.

The practice of most ranchers of looking after animals for ranchers from outside the reserve during wetter periods (78·6% of respondents) indicates that the land is not given time to recover after droughts as the herds build up. This practice is potentially damaging to the vegetation, but is also an important source of income to the inhabitants (communal ranchers are paid about N$10 per cow per month to look after other peoples' cattle. (N$ = Namibian dollars; there are currently about 7·1 Namibian dollars to the U.S. dollar.)

Otjimbingwe pastoralists do have strategies to deal with changes in environmental conditions, such as moving to other areas, renting or receiving grazing land free-of-charge on commercial land, or selling their stock. However, these options are limited by the large areas occupied by commercial ranches. The large numbers of people who either depend on government drought relief payments (57% of respondents) or leave to work in urban areas (17·9%) indicates that many actions are by force of circumstance, rather than by choice.

Changes in water, wild plants and animals

All respondents considered there to have been a decline in the amount of rainfall over time, and that this was the main cause of land degradation in Otjimbingwe. However,

there has been no long-term change in rainfall (Fig. 4). Considering the average level of education of our respondents, it may seem unlikely at first glance that this response would have been influenced by international discussion of concepts such as global climate change. However, many people in Otjimbingwe and surrounding areas possess a radio (69–79% of households—Paskin *et al.*, 1996) and may have acquired knowledge of such concepts from this source, thereby influencing their answer. Alternatively, the extreme variability in rainfall between years may limit the ability of people to perceive the magnitude of deviations from the long-term mean (Behnke & Abel, 1996). The period over which people perceive average rainfall may also influence their perceptions because runs of drought years have been longer in the last 10–20 years than in the 1960s, for example. People may also remember extreme rainfall events and perceive them as the norm, thereby considering years with rainfall close to or even above the long-term mean as 'drought' years. Interestingly, complaints about declines in rainfall are not new among the Hereros. C.J. Andersson (1856) noted 'The Namaquas [read Namas], as well as the Damaras [read Hereros], are loud in their complaints that less rain falls now than half a century back'. In a similar vein, Thomas & Sporton (1997) note that native pastoralists in central Botswana link declines in wildlife and edible wild plants to drought and not to hunting pressure or stock management.

The respondents' observations on water quality were consistent with the data we obtained independently on water quality. However, their lack of observation on changes in water quantity may be due to the fact that the decline in water yield has not yet reached a threshold that affects the rate or frequency at which they withdraw water from the boreholes. Nonetheless, this measured decline in water quantity is a cause for serious concern, particularly as the human (and livestock) populations continue to grow.

The widespread perception (all respondents) that the availability of 'uintjies' (*Cyperus* sp.) has decreased over time in Otjimbingwe is peculiar because Frederick T. Green in a letter to C.J. Andersson, dated 12 May 1864, states 'The Berg Damaras [read Damaras] no sooner trek in [to Otjimbingwe] than they are compelled to leave again for the same cause, as they subsist almost entirely on 'uintjies', which cannot be procured here' (Lau, 1989). Von Francois (1895) recorded 'uintjies' as being plentiful on mountain slopes (there are no mountains in Otjimbingwe). Büttner (1879) recorded the seasonal abundance of 'uintjies' and the fact that the Damaras gathered bags-full of them and bartered them with the Hereros in Otjimbingwe in the 1870s; the price being an undressed sheepskin for a 'bokzak' (Dutch for a 'goat bag') filled with 'uintjies'. This observation further emphasizes the fact that the Damaras were not resident in Otjimbingwe at the time and that they owned no stock, and that the Hereros already owned small stock such as sheep with which they could barter. We tentatively suggest that the reason for the misconception that 'uintjies' have declined in Otjimbingwe (when they probably never occurred there in any great quantity) is that stories of great 'uintjie' abundance have been passed down by the Damaras from the time when the 'uintjies' were indeed abundant when they lived in the mountains east and south of Otjimbingwe.

All respondents in our first survey considered the numbers of wild animals to have declined in Otjimbingwe over time. This perception is consistent with the data we have. For example, Andersson (1856) noted the presence of large game animals, including a black rhinoceros *Diceros bicornis* (and calf; i.e. evidence that they probably bred locally), as well as many interactions with lions *Panthera leo*, zebras *Equus zebra hartmannae*, gemsbok *Oryx gazella* and wildebeeste *Connochaetes gnu*. None of these species occurs in the vicinity today. Only one species of large mammal, the steenbok *Raphicerus campestris*, has been seen by us over a 3-year period, or recorded by the respondents, in recent years in Otjimbingwe. Contrastingly, gemsbok, springbok *Antidorcas marsupialis*, and kudus *Tragelaphus strepsiceros* are all fairly abundant on the surrounding commercial ranches (pers. obs.).

Conclusions

The long-term residents of Otjimbingwe recognize that a number of environmental features of the area have changed and degraded over time. This identification of a problem, albeit with an occasionally misplaced concept of the source thereof, suggests that there exists considerable potential for remedying the environmental situation in Otjimbingwe. However, the limited alternatives available to these people due to lack of alternative ranching practices suitable in the extreme environment, outside pressures causing limited flood water in the river, restricted freedom of movement for their animals during drought periods, and little or no management strategy at the community level make the likelihood of changes in the situation rather remote under current circumstances. Feasibly, improvement in the quality of life of Otjimbingwe's inhabitants can be obtained by a change in the policy of the Namibian Department of Water Affairs to take downstream populations into account when regulating water use from dams and to inform them of the potential reduction of water availability at boreholes in the future. Furthermore, community-based (as opposed to individualistic) decision-making for mutual benefit may also help to minimize the depletion of resources, especially those near watering points where demand is highest.

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