Changes in Landscape or in Interpretation? Reflections Based on the Environmental and Socio-economic History of a Village in NE Botswana

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SUMMARY

In semi-arid Africa, environmental change continues to be debated, focusing particularly on the status and significance of land degradation and on local versus scientific knowledge claims. This paper suggests an approach for using different types of data sources, and for bringing together understandings of ecosystem dynamics and of people's interaction with the environment, and thereby achieving 'closure' in a highly contested terrain. The environmental and socio-economic history of a village in north-eastern Botswana is investigated using oral histories of villagers, aerial photographs (1964 and 1988), and official records. At first, descriptions of the environment appear confusing and contradictory, and at odds with official records. Rainfall is the focal point around which most explanations of environmental change turn. Here scientists find no long-term change, while villagers perceive a decline. Overstocking has been a main concern for policymakers throughout this century, while villagers do not see this as a problem. These, and ensuing contradictory perceptions, are partly resolved by identifying the main components linking the wider society to the local and to the environment, and by seeking a shared meaning between local and official versions, as well as between different local versions, of environmental change. We found, instead of contradiction, a striking convergence between, on the one hand, recent scientific understanding of the unpredictability and complexity of semi-arid dynamics and, on the other hand, the description and explanation of change offered by villagers themselves.

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INTRODUCTION

This is a schematic environmental history of a single village, Kalakamate in North East District, Botswana, over the main part of the present century. The paper interprets part of a body of primary data collected from 1990 to 1994, and focuses on specific aspects of the interface between social and environmental change, and on the challenges involved in analysing local people's interpretation of a changing environment. (The present paper essentially corresponds to the first six sections of paper III in the doctoral thesis by Dahlberg [1996]. Only a few recent references have been added.) The study mostly relies on interviews with older people, and these are corroborated, tested and interpreted using secondary data sources such as aerial photographs and records of rainfall, human population, and livestock. The current scientific debate about range ecology of semi-arid areas is highly relevant to the questions raised and forms part of our interpretation of the data. Clearly there are serious methodological and epistemological challenges in bringing together such sources. How are opinion and fact to be identified and differentiated? Under what circumstances should 'closure', i.e. a single and most credible interpretation, be sought, and when should a regime of additive pluralism be allowed to remain? When should one data source be privileged over another?

These problems are unavoidable when views grounded in different cultures engage. Often in this study, a resolution of seeming contradictions requires further detailed information which is simply unavailable, or the physical processes operating are not fully understood by anybody – scientist or farmer. However, on some issues the inclusion of information from different sources provides detail enough for a resolution to be approached with some certainty. The environmental history of this part of Africa is particularly interesting in the light of the post-colonial discourse on people and the environment (Dahlberg 1994, Thomas and Middleton 1994). Where colonial administrators and post-colonial consultants saw widespread degradation caused by overstocking and indigenous ignorance, contemporary range ecologists and rural sociologists more often see environmental resilience and successfully applied indigenous knowledge.

For many areas of Southern Africa detailed environmental time series data are sparse. Aerial photographs seldom exist for periods before the 1950s, and for both early and late photo-series the area covered was often limited. In addition, photo-coverage is usually repeated only at intervals of a decade or more, making it problematic to differentiate between continuous change and short-term variation. Historical documents, when they exist, can be of great value. However, they seldom provide authoritative or detailed information on the environment. Ecosystem monitoring is becoming more common, but it is usually either very large-scale and/or conducted for a single land-use purpose, and in all cases time-series are still short. Also, the understanding of semi-arid ecosystems has changed fundamentally in recent years, with dominant ecological dynamics claimed by many to be event-driven and characterised by drastic events, random variation and resilience (Behnke and Scoones 1993). This puts new demands upon existing data, and renders our spatial and temporal gaps even more problematic, since the events themselves and subsequent changes may be obscured by the sparsity and irregularity of data points in space and time.

Rehearsals of data inadequacies in sub-Saharan Africa are of course commonplace, and provide few surprises. They are stated here to outline the opportunities and constraints involved in constructing an environmental history, and to explain the methods we adopt in the interpretation of diverse and contradictory information. Interpretations that focus on the local environment have been sought, and influencing factors from the social and physical sphere will be discussed in relation to observed and inferred changes of such environmental factors as availability and condition of land for grazing and farming (including crop productivity and soil fertility), water availability and signs of soil erosion.

A long time horizon assists us in assessing the significance and probability of the many different views and also the limitations of policy and regulation. Also, to the extent that the narratives of local farmers and new findings in range ecology are correct, a long time horizon is essential for most statements on environmental change in the semi-arid regions. One of our more unsettling conclusions is that the history of policy decisions, which were often based on now discredited hypotheses, is full of unexpected outcomes in how it affected this village. The most important variables which influenced environmental outcomes were either single events, both in the social sphere (e.g. the proclamation of the Protectorate, and later of Independence), and in the physical sphere (e.g. droughts), or policies enforced without sufficient attention to possible environmental impacts (e.g. prohibition of fires, erection of fences). The approach adopted has enabled us to explain many of the apparent contradictions, and to combine the diverse sources of data. In several cases, contradictory descriptions of environmental change were resolved when the spatial and temporal generalisations made were analysed. With this approach, many earlier assumptions of land degradation in the area can be questioned and, at least in some cases, refuted.

THEMATIC FRAMEWORK

Any environmental history requires an overall framework which identifies the main components of the environment, the society which perceives it and imbues it with symbols and meaning and which transforms it through time, and the processes acting upon both. Figure 1 identifies these components in a context specific to Botswana. They are mostly based on the narratives of the local people,

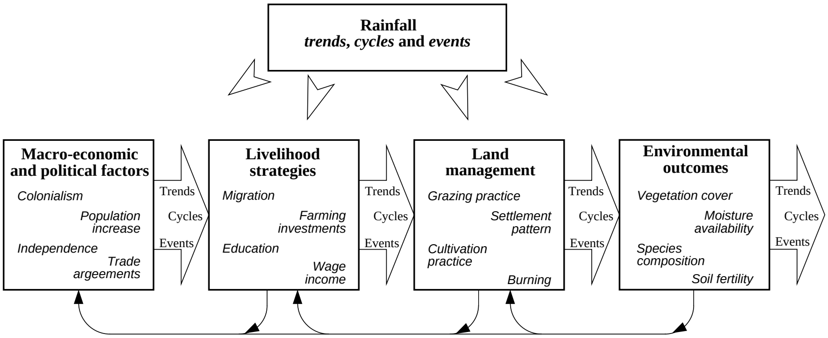

FIGURE 1. Components and processes of environmental change

Environmental outcomes can be characterised by, for example, species composition and frequency, vegetation cover, type and magnitude of soil erosion and moisture distribution. Changes may occur as events, cycles or trends as a result of natural and/or socially induced causes. People affect the environment directly through land management decisions concerning such practices as burning, cultivation, grazing of livestock and settlement pattern. The choice of specific practices depends on the physical and social setting, and variations in management may occur as isolated events, or as cycles or trends, depending on physical factors like rainfall, and changes in people's livelihood strategies. As the structure of a household changes over time, strategies may change. This is, however, often interrupted by events at the individual or family level which may have far-reaching implications for land management. Livelihood strategies also change along with general shifts in the community and wider social sphere. Macro-economic and political factors influence and shape patterns of change at the local level. Events may have a short-term or long-term influence, and cause different impacts depending on the local setting. A trend which may be clear at the national level may be difficult to identify at the local level. (See also Thomas & Sporton 1997.)

but labelled by the researchers. We have also indicated the importance of separating different types of change (trends, cycles and events). Most environmental histories which choose to use both narrative and formal secondary sources have to interpret the interpretations of the informants, which in turn requires some exogenously constructed logical 'architecture', or thematic framework. Leach et al. (1997) also outline a similar epistemological approach. However, our differs in emphasis somewhat since it seeks 'closure' and convergence between scientific and folk explanations, rather than to construct a 'counter-narrative' to dominant, scientific and western ones. This helps to resolve a number of contradictions in the attribution of cause and effect by informants themselves. Wherever possible, we constructed socio-environmental relationships from the informants' narratives. There is a constant danger that such interpretations reduce the independence and authenticity of the local narratives, and instead become a ventriloquisation by the researchers. The focus of this study is on the four main components: macro-economic and political factors, livelihood strategies, land management, and environmental outcomes – and on the linkages between them.

STUDY AREA

The North East District was chosen because historical documentation of this area, having been early settled by the British, was comparatively good. Environmentally the district is of special interest, following '...more than half a century of official lamentation about the condition of the range and predictions of imminent ecological disaster' (Fortmann 1989: 197). A description of the village of Kalakamate (fig. 2), has been presented in more detail elsewhere (Dahlberg 1995).

Depending on the period selected and how the borders are defined, the area of Kalakamate has varied between today's approximately 70 km^2 and perhaps as much as 90 km^2. Traditionally the eastern and western borders were the seasonal

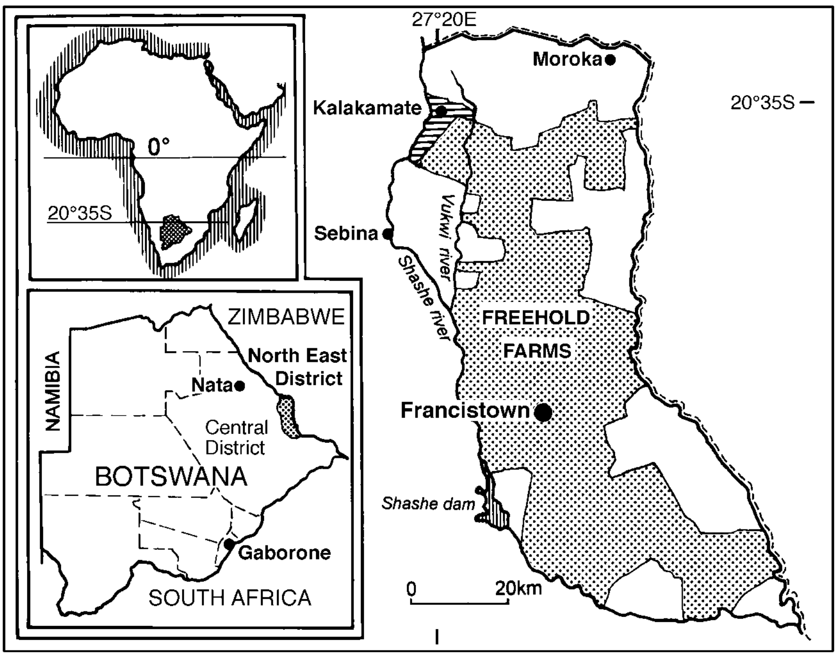

FIGURE 2. Botswana with North East District and the village of Kalakamate

rivers Vukwi and Shashe respectively. However, early this century a large tract of land to the east was acquired by the Tati Company, a private company founded when the Bechuanaland Protectorate was created in 1885. Until the 1950s this land was accessible to village livestock, but then the land was fenced, and in the late 1980s the village borders were changed again when a veterinary cordon fence was erected in the north and north-east. The tributaries of the two major rivers cut across a gently sloping land with scattered granite kopjes and ridges of dolerite intrusions and amphibole rocks (Botswana 1975). Soils have developed mainly from gneiss and granite, but also from basic rock, and may vary markedly over short distances. In most parts of the study area soils are shallow with a high content of gravel, moderately to well drained and with textures varying from loamy sand to sandy clay loam. Regosols, luvisols and leptosols are the common soil types, while narrow strips of alluvium are found along rivers and streams. To the south a large expanse of vertisol, a heavy dark clay, is found (Botswana 1984, Radcliffe 1990, and for local descriptions of soil types see Dahlberg 1996: III).

Rainfall is extremely varied, both between and within years, and the last 15 years have been characterised by recurring agricultural droughts. The area has long been settled by Kalanga-speaking people, agro-pastoralists whose history and language differ from that of the Tswana in the south (Werbner 1975). Since the turn of the century different Setswana-speaking groups, predominantly the Khurutse, have also settled in the village. All land is affected by human use, but areas not used for cultivation, now or recently, are covered by dense woodland and bush-savanna. *Colophospermum mopane* dominates among the woody species, with other common genera being *Acacia*, *Combretum*, *Commiphora*, *Terminalia* and *Grewia*. Common grasses belong to the genera *Aristida*, *Eragrostis*, *Digitaria*, *Tragus* and *Urochloa*.

METHODS OF DATA COLLECTION

Data were collected from archival documents, rainfall measurements, records of livestock and population, aerial photographs from 1964 and 1988 (Department of Surveys and Lands, Gaborone), field observations and interviews with 42 villagers, i.e. 6% of the village population. (Aerial photographs are available also for 1971 and 1981, and preliminary inspection of these indicates that the main results would not be influenced by their inclusion.)

Old people were targeted for the interviews (see table 1), and approximately 35% of the villagers aged 50 or more were interviewed. This naturally means that younger people's use and perception of the landscape, likely to be at odds with those of the elders, were not recorded. However, by concentrating on the old men and women, one can reach further back in time to identify the practices, events and circumstances likely to have had an impact on the transformation of the

Characteristics	Women	Men	Total
Residence:			
Born in Kalakamate – stayed there always	13	4	17
Born in Kalakamate – been away for period >10 yrs	1	10	11
To Kalakamate as child – stayed there always	2	–	2
Moved to Kalakamate at marriage	9	3	12
Occupation:			
Only (ever) a farmer	20	2	22
Farmer now – other occupation before	2	10	12
Farmer and civil service job	–	2	2
Farmer and manual job	3	2	5
Too old and sick to farm	–	1	1
Number interviewed	25	17	42
Median age	61	70	63

TABLE 1. Respondents (Kalakamate, 1992 and 1994)

landscape over the past fifty or sixty years. A roughly equal number of men and women, as well as an even spatial distribution in terms of homesteads and fields, was aimed for. The interviews were conducted in the growing seasons of two hydrological years, 1991/92 (a dry year) and 1993/94 (a year with average rainfall), and the different characteristics of these years were taken into account during the interviews and when analysing responses.

The interviews were open-ended and often long, sometimes lasting many hours, in which case they would extend over a few days. Most were conducted at the fields, or when walking through the surrounding grazing land. A middle-aged man from the village, a former teacher, assisted as an interpreter in the two local languages Kalanga and Setswana. Efforts were made to avoid misunderstandings due to prejudice, suspicion, differences of culture and gender, as well as pure translation errors, but of course these will still have occurred. It should also be noted that the semi-structured nature of the interviews meant that different topics were highlighted with different respondents, and that on several issues responses were collected only from a part of the sample group. (For a list of respondents and questions see Dahlberg 1996: III.) What we present is our interpretation based on this procedure.

Aerial photographs can provide important and detailed information about environmental features and about past and present land use. With rapidly improving techniques for the interpretation and presentation of data, their value is even more enhanced. Black and white photographs for the study area were obtained from 1964 (*c.* 1:36,000), 1971, 1981 and 1988 (1:50,000). An advanced stereoscope (Interpretoskop B, Zeiss, Jena) giving a three-dimensional view of the landscape was used for interpretation. This way a high spatial resolution is achieved, allowing objects of 1-2 m to be detected. Different features and land-cover types were drawn directly on transparent overlays and checked in the field (1992 and 1994). For analysis and presentation, GIS software ARC/INFO and ArcView were used to geocorrect the overlays (using the official topographic map over Botswana, scale 1:50,000, UTM grid coordinate system). To this end the overlays were scanned, and a number of ground control points identified which could be recognised in the photo as well as in the topographic map. These were then used to produce the transformation equation with which the overlays could be digitally converted to match the topographic map. For a complete match, height differences in the terrain must be taken into account, but this level of accuracy was not necessary for the present purposes.

So-called ‘hard’ data also entail an interpretation, and one should acknowledge the subjectivity of all actors involved in the assessment of a particular landscape and its chains of causes and effects. Scientists choose how to use and classify aerial photographs (for a discussion of problems involved see e.g. Larsson and Strömquist 1991, Dahlberg 1996), and how to order records of such parameters as population, livestock and rainfall. Colonial administrators chose when and where to travel, and what to record. Different groups have their distinctive cultural and professional repertoires, and when interpreting the data, the agendas of the actors have to be acknowledged.

THE INTERFACE BETWEEN ENVIRONMENT AND SOCIO-ECONOMIC CHANGE: LIVELIHOODS

The concept of livelihood strategy is useful for linking changes in environmental management to social change, and therefore also in studies of the causes of environmental change (Blaikie 1985, Blaikie et al. 1994). Here we focus on the access enjoyed by different farming households, and individuals within them, to a range of income opportunities. Of these, a selection is made to provide a portfolio which forms a ‘livelihood’ (numerous examples are presented e.g. in Scoones and Thompson 1994, and Steenhuijsen Piters 1995). Some of these income opportunities will involve the use of local natural resources (e.g. the cultivation of crops), while other will not (e.g. the migration of young males to sites of non-agricultural employment). Some will involve a cash transaction (e.g. wage labour or the sale of agricultural produce) and some will not (e.g. the collection of firewood for household use). In the present context it is important to understand the different livelihood strategies and their components since they all have significant, though sometimes indirect, impacts upon environmental management.

The household livelihood strategy is also a useful concept for tracing the influence of more general socio-economic changes and events at the regional, national or international scale upon local changes in natural resource use. These changes are mediated through a range of local decision-making strategies which have environmental impacts. However, generalisations about processes aggregated to the national or even international level, although useful for communicating diverse experiences of a shared reality, are partly fictitious and should be treated with caution.

Population growth and livelihoods

One of the trends least mentioned by villagers, but which may affect their livelihoods, was the growth of human and livestock populations. These two factors are those which have dominated range ecology and neo-malthusian thinking, over the past sixty years or so. Increases in the populations of humans and livestock in the tropics and sub-tropics have often been assumed to result in increased pressure on natural resources, and thus to heighten the risk of land degradation. Although this may indeed be a credible explanation in some instances, the relationship is often far from clear, as recent studies of the Machakos District in Kenya have shown, where population pressure contributed to an intensification of land use and the incentive to invest in longer term conservation practices (Tiffen et al. 1994). A broader range of adaptations to population growth which include intensification, a rise in the value of land relative to labour, and new conservation technologies, have been empirically studied in a number of case studies of farming systems elsewhere in Africa (Turner et al. 1993). More specifically, it is important to differentiate between an overall population increase in a country or district, and an increase of population density in specific parts of these areas. Due to such factors as alienation of land (e.g. private farming or state control), migration, and urbanisation, the latter may differ substantially from the former.

The national population of Botswana has increased from a count of 120,778 in 1904 (Vanderpost 1992), to 1,326,796 in 1991, giving an average annual growth rate of 2.79% for the whole period, and 3.49% for the period 1981 to 1991 (CSO 1982, CSO 1992). The part of the country that later became North East District has experienced drastic changes in population densities (Tapela 1982). It is believed that agro-pastoralists and hunter-gatherers occupied the land for at least a thousand years. In the 19th century the land was heavily depopulated and population densities were very unstable due to war (ibid.). At times of calm people would move back, and be joined by groups from other areas, only to flee or move again in the face of renewed raids and land shortage. At the turn of the century the area of the present North East District was divided between company land, the Tati Concession, and the so called Tati Native Reserve, severely limiting local people's use of land for agriculture and grazing (Werbner 1970).

Figure 3 (a–d) shows recorded changes in resident population at the scale of nation, district, chiefdom and village. These records should be treated with

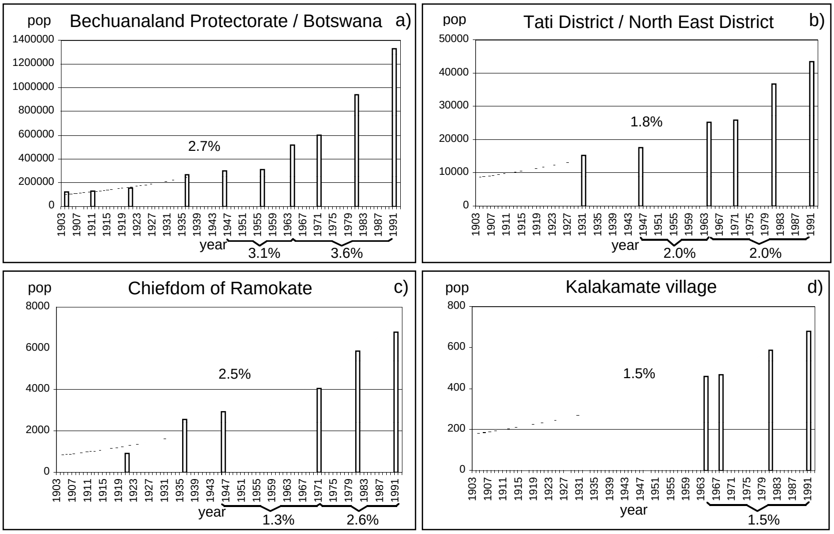

FIGURE 3 a–d. Change in resident human population in four areas.

To facilitate comparisons between the graphs, we have – in spite of the sparsity and unreliability of data – computed curves as a least squares exponential fit over the whole period considered, and the numbers next to the curves give the corresponding growth rate in percent per annum. We also give equivalent average annual growth rates as numbers below designated intervals on the time axis. In diagram B, numbers for 1931 and 1946 refer to Tati District (North East District after 1966) including Francistown (which then had a small population), while numbers for later years exclude Francistown. For sources see note 1.

caution due to changing enumeration areas and lack of detailed data on migration (Tumkaya 1987). According to the records, the population of Kalakamate grew from 457 to 678 between 1964 and 1991, i.e. an average annual growth rate of 1.47% (BNA CENSUS 39/4, CSO 1992). This is much lower than the national and district average for the same period. It is also lower than the average for the Chiefdom of Ramokate, of which Kalakamate is a part, although these figures do not cover exactly the same period. Population density has increased in Kalakamate, due to a combined effect of population growth and a decrease of the area available for grazing and cultivation. However, density estimates for the northern part of the district are in the range of 25–35 persons/km^2 (NEDC 1986, Hoof and Maas 1991), whereas an estimate for Kalakamate is approximately 10 persons/km^2. A trend of population increase has occurred in all areas, but the slope of the trendline varies for the same, or roughly comparable, time periods. While an exponential trendline fits the national data, this is not as evident for smaller areas (fig. 3).

Even if population has shown an overall increase, variations between areas must be considered in any explanation of perceived environmental change. Locally, changes in livelihoods, including seasonal and temporary migration, have had a profound impact, arguably greater than an aggregate population increase. Male migration to the mines in South Africa was especially high during the first half of the century (Schapera 1947), but fluctuated widely depending on the economic and political situation (Tumkaya 1987). This was characteristic also for Kalakamate, where 70% of the interviewed men had worked outside the area for periods varying between 7 and 46 years, and as many as 40% had been away for more than 20 years. In Kalakamate, as elsewhere, the effect of male migration on local land use will vary, depending on factors such as length of absence, frequency of visits home, age and sex of remaining family members and local sources of income (cf. Hesselberg and Wikan 1982).

The majority of the interviewed men were able to return to the village every year during the ploughing season, for periods varying between one and three months. There was no indication that migration had changed such cultivation practices as type of crops, or methods of ploughing and planting, and remittances were seldom used for such agricultural improvements as fertiliser, fencing material or improved seeds. However, money from wages did add to food security, especially necessary in times when the household could not plough as much land as needed or at the most favourable time, e.g. because of labour shortage. Wages were also used to pay for help with clearing, ploughing and harvesting, and especially to build up the household herd of livestock. The latter served as an insurance, and also improved a household's chances of better yields. Concerning increased opportunities to acquire cattle, the aggregate statistics of cattle numbers discussed below suggest that the ability to increase herds on a stable basis was limited to a few households, and did not result in a trend of rising cattle numbers in the village. It should be noted that households also utilised other strategies to overcome the labour shortage resulting from the husband's absence. The wife may stay with her parents-in-law and help in their field, or receive help from them, her own parents or other relatives to plough her own field.

Since Independence in 1966 there has been a marked drop in migration to South Africa (CSO 1991), and in 1991 only 1% of the population in Kalakamate was listed as working abroad (CSO 1994), while instead both men and women look for work in the towns of Botswana. This is a further change from earlier times, when only men migrated, while the women stayed at home looking after fields and livestock. Throughout Botswana livelihood strategies have changed, reflecting a diversification of income sources away from farming and livestock, and a generational change in perception of the role of agriculture. It is common today to hear villagers say that in dry years they do not bother to plant, that at the most they will plant only a small area, and that the young people lack an interest in farming. Instead, wages and drought relief are used to buy the necessary staples. These changes have two important environmental impacts. Land management has changed, not so much in actual practices (e.g. what crops people grow) as in patterns over space and time (e.g. where and when to cultivate), and this may have direct and indirect influence on the environment. Furthermore, changes in livelihood strategies influence the way people perceive and value the environment, and thus environmental changes occurring today cannot be judged according to criteria of good and bad used several decades ago (and vice versa).

Livestock numbers and livelihoods

Turning now to changes in stocking populations and densities, the differences between national and regional trends and local variation are very pronounced. At a national level the cattle herd of the communal rangelands has increased at least eight-fold since the turn of the century (Abel 1992). Dramatic fluctuations, caused by drought, diseases and market factors are superimposed on this trend of increasing cattle numbers (Roe 1980). Figure 4 (a–d) shows recorded cattle numbers for years with available records for different areas in north-eastern Botswana. Approximate geographical location and size of these areas are shown in figure 5. These data should be treated with caution. As sources differ, so do methods and timing of counting, the area included in a certain designated region may vary substantially over time, and the records make little mention of such events as eviction of cattle, temporary removal to cattle posts and freehold lands, or the opening up of new grazing areas (see notes to fig. 4). Furthermore, many archival sources are vague about exact dates, and it is sometimes impossible to be sure to which year certain cattle numbers refer.

As a first example of this uncertainty, Francistown Veterinary Region (later called Francistown Agricultural Region) covers both communal land and private ranches, in both North East and Central Districts, and also includes an extensive salt pan. The area and definition of this region has varied widely over time. Furthermore, commercial ranching has gradually become more important over the last four to five decades due to the eradication of tsetse fly, the drilling of wells, and new policies favourable to cattle rearing. The dramatic increase for the whole area therefore says little about changes in stocking rates on communal land. The other areas shown in figures 4 and 5 are all communal land, while Kalakamate village is part of Ramokate’s chiefdom, which in turn is part of the former Tati Native Reserve, i.e. the area in northern North East District not taken up by freehold land. It should be noted that cattle numbers presented for these areas may actually lead to an overestimate of the grazing pressure on communal land, since for at least part of the year many of these animals would be grazing on land belonging to the Tati Company, either illegally or by rental agreements (Schapera 1971). In these areas any trend of increasing cattle numbers is hard to discern. It may be noted that whereas in 1936 the Tati Native Reserve held 34% of the cattle of Francistown Veterinary Region, this proportion has fallen

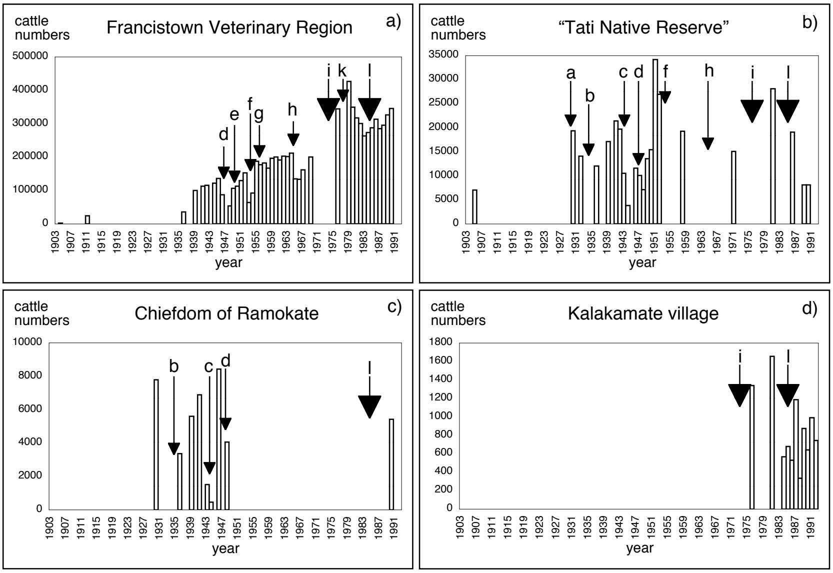

FIGURE 4 a–d. Change in cattle numbers in four areas

Numbers for the area previously called Tati Native Reserve 1981, 1986 and 1989, and for Kalakamate 1981 are estimates based on available numbers given for individual communal areas. For sources see note 2. Arrows and lower-case letters represent events which had a strong effect on cattle numbers:

a) 1930: Cattle numbers for Tati Native Reserve include cattle kept at cattle posts in Matsiloje, an area SE of Francistown – but these did not exceed 3000 (Kinlund 1995).

b) 1933–35: Severe droughts, high cattle mortality (Roe 1980).

c) Nov–Dec 1943: Enforced destocking of cattle in the Tati Native Reserve. 6,732 head of cattle were removed from the whole reserve, of which 1,065 were removed from Ramokate's area (BNA S.238/9).

d) 1946–47: Severe drought with heavy loss of cattle. Also some voluntary removal of cattle from the reserve (BNA S.238/7/2).

e) 1949: The colonial government started up ranching ventures around Nata (Blair Rains and McKay 1968).

f) 1951/52 and 1953/54: Severe droughts.

g) 1955 to 1956: The area of the Bokalaka (i.e. between Tutume and the border to Southern Rhodesia [Zimbabwe] and the Tati District) was included in the Francistown Veterinary Region (Fortmann et al. 1983). From 1956 and onward the pace of borehole development in the central and western areas of the Francistown Veterinary Region increased (Blair Rains and McKay 1968, Roe 1980).

h) 1963–65: Severe droughts.

i) 1970s: Almost all years gave abundant rainfall. Also, Nata Crown Lands were included in the Francistown Veterinary Region (Fortmann et al. 1983).

k) 1975–1978: Areas around Nata were allocated for commercial ranches within the TGLP scheme (i.e. the Tribal Grazing Land Policy) (Sandford 1980, White 1993).

l) 1982–1989: Almost all years with below average rainfall, severe agricultural droughts.

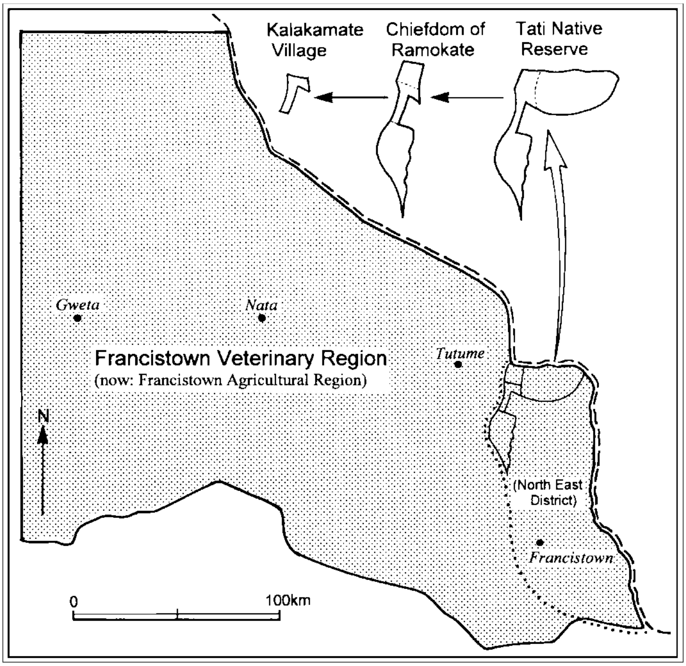

FIGURE 5. Areas referred to in figure 4

The grey area shows the whole Francistown Veterinary Region, the broken straight line shows the national border, while the dotted line shows the district boundary.

drastically and (except for fluctuations in the 1940s) fairly evenly to 9% in 1981, 6% in 1986 and 2% in 1989.

An environmental impact ascribed to increasing cattle numbers in one area cannot simply be extrapolated to others. Neither can changes in livelihood opportunities through time be inferred in a general manner. It is well established that ownership of cattle varies very much among households in Botswana. Most households own no or very few cattle, while some own large herds, and it is those with few who are likely to suffer worst in a drought or epidemic (Roe 1980, Sandford 1980, White 1993). The local history, as told by villagers in Kalakamate, relates how fortunes have fluctuated over time. All but one of those who owned cattle at the time of the interviews, or who previously had owned cattle, stated that over the last decades their herds had declined, often by 70%–100%. Many animals had died in the recent droughts in the 1980s and in 1992, but other unrecouped losses, experienced in droughts in the 1940s and 1960s, were also recounted. Villagers perceive lack of rainfall as the main cause of death of cattle, but they were also concerned about shortage of grazing land. However, this is not seen as caused by any increase in cattle numbers, but by the alienation of grazing land through the fencing of freehold land, by the veterinary cordon fence, and to some extent by reduced accessibility to grazing lands because of the recent centralisation of the settlement, as discussed below.

Changing land use and livelihoods

In many parts of eastern Botswana, the common practice since at least the mid-19th century until shortly after Independence was large and nucleated settlements. Land use was divided, with cultivated areas situated at a distance from the settlement, and pastures located even further away (Silitshena 1979). Since Independence there has been a move back to the lands, with people staying permanently in small scattered settlements close to their fields and cattleposts (Silitshena 1982). The ways in which these spatial patterns change differ throughout the country and cannot be assumed, or extrapolated from findings in other areas (see e.g. Hesselberg 1985). As discussed further on, the exact nature of these patterns can have a strong impact on the local environment, and on how environmental change is perceived.

Land use in Kalakamate can be characterised as a mixed farming regime, where livestock holding is combined with cultivation, and where people depend to a large extent on local natural resources for building material, fuel and supplementary foods. Most households work the land for crops, although few (if any) are solely dependent on agriculture. In agreement with other studies (Roe 1980), respondents state that farming practices have changed very little over the last sixty years. Tractors are still uncommon, the application of kraal-manure and fertiliser remains virtually nil, soil conservation measures are basically restricted to contour ploughing, only a couple of improved crop varieties are sown, and it is only in the last decade that wire fencing of fields has started to become common.

While reported farming practice may have changed little, its spatial pattern within the village has changed considerably, and in some ways in the opposite direction from what has happened in areas further south, mainly settled by Setswana-speaking groups. The traditional settlement pattern among the Kalanga of the north-east was one of extended families with homesteads scattered throughout the area (Werbner 1970, 1975). Each cluster of huts was surrounded by the families' fields, and livestock was herded on the nearby grazing land.

As part of the process of improving livelihoods after Independence, the state initiated and strongly encouraged the nucleation of settlements, to facilitate access to such amenities as water, schools and clinics. This, in combination with other outside interventions, resulted in a change of the spatial pattern of natural resource utilisation. The change in settlement and cultivation pattern in Kalakamate between 1964 and 1988, as interpreted from aerial photographs, is shown in figure 6 (a–b). Classifications (also for 1988) are based on what could be

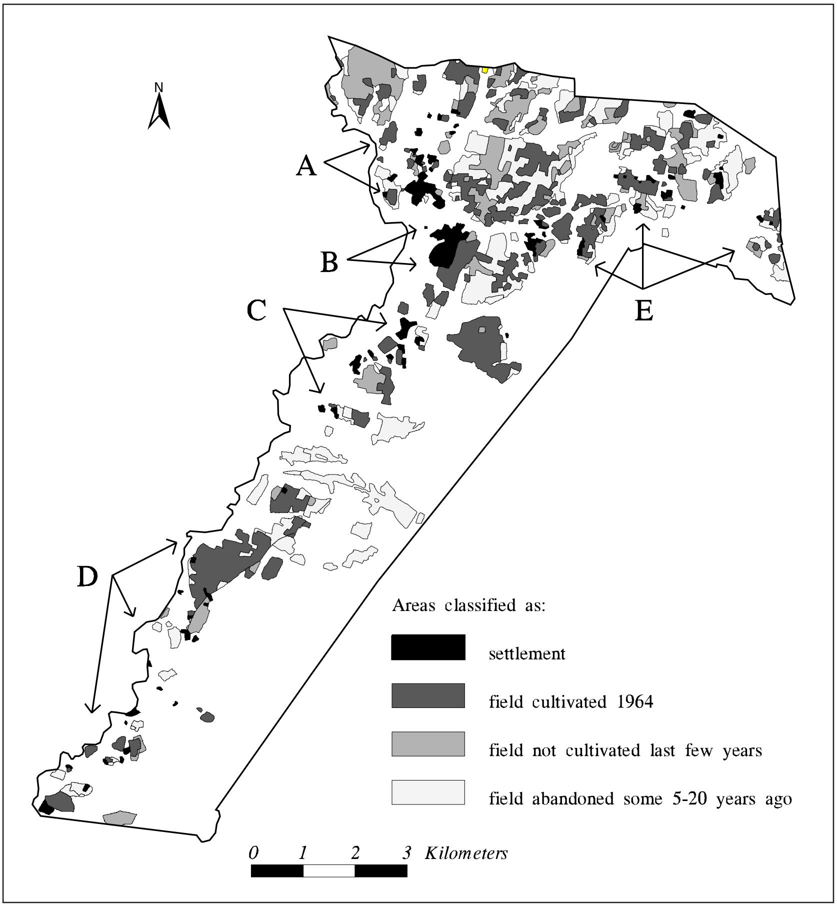

FIGURE 6 a. Settlements and cultivated land in Kalakamate 1964.

Figs. 6a and 6b are based on interpretation of aerial photographs, and are geocorrected using the official topographic map over Botswana (scale 1:50,000, UTM grid coordinate system). In both figures the remaining unmarked white area is classified as grazing land, i.e. areas with varying densities of woody vegetation and grass cover.

identified in the photographs to make the comparison as unbiased as possible. Thus for 1988 the class 'field abandoned some 5–20 years ago' will include some, but not all, of the fields cultivated in 1964 and later abandoned.

Individual compounds are usually clearly visible in the aerial photographs, although the number of households per compound cannot be determined. Compounds were counted throughout the village (table 2). Two areas have experienced an increase in the number of settlements: the area around the kgotla (the chief's office and the village meeting place), where the school, the clinic and

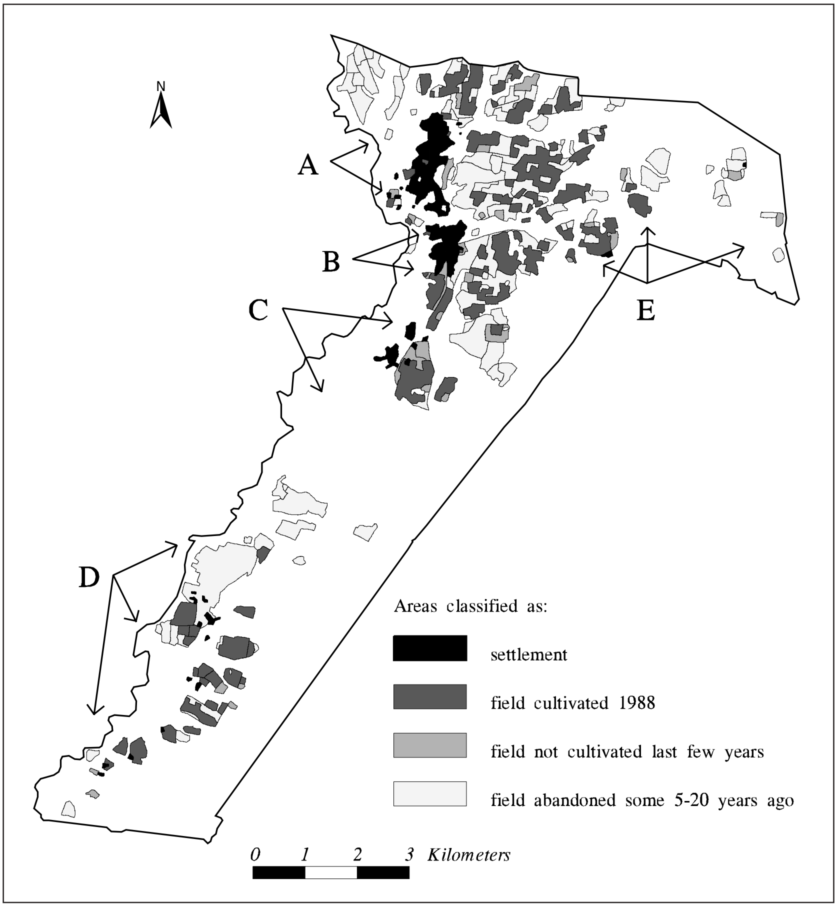

FIGURE 6 b. Settlements and cultivated land in Kalakamate 1988

Location	**Number of compounds**	
	1964	*1988*
near kgotla (A)	26	76
at crossroads (B)	19	40
area just south of B (C)	13	11
area even further south (D)	25	15
area to the east (E)	28	2
Total	111	144

TABLE 2. Location and number of compounds in 1964 and 1988

Letters in brackets refer to the main text and figure 6.

other services are now located (area indicated by arrows A in fig. 6); and the area by the crossroads just south of this (B). From here a tarred road runs south, and along this (area C), as also further south (area D, along the old main road), the number of compounds have decreased. The area to the east (E) has lost all permanent habitations. Of the two compounds found in area E in the 1988 photographs, one provides temporary housing during the growing season, and the other had been completely abandoned by 1992. Hesselberg (1985), studying two other villages in north-eastern Botswana, found a similar pattern of movement to the main village, especially by the poor and landless and by the most wealthy who can employ extra labour.

Areas designated as ‘fields not cultivated last few years’ are easily identified in the photographs since here woody vegetation is very sparse and fences are still clearly visible. However, one cannot determine whether these fields are abandoned, or simply left fallow for one or a few years because of lack of rainfall or other constraints. Fallow here means resting, i.e. periods without cultivation. Areas classified as ‘field abandoned some 5–20 years ago’ are former fields left fallow for more than approximately five years. These areas have become so overgrown with dense thornbush that people very rarely invest the labour needed to clear them. Such land is usually left for periods of 20 to 40 years or longer, until the thickets of thornbush have been replaced by a more open shrub- and woodland. These areas can often be identified on aerial photographs many decades after abandonment. However, as can be seen in the maps, some areas ploughed in 1964 can no longer be identified as fields. This is mainly because in some areas, usually with soils derived from basic rock, the secondary vegetation quickly merges with the surrounding woodland. The remaining unmarked white areas in figure 6 were classified as grazing land, and analysis of characteristics and changes in these areas are presented in section 7 of Dahlberg (1996: III).

In general, proximity to the borehole, the school and other services, was the main reason for building a new homestead in or close to the main settlement, and with the move of settlement followed a move of areas of cultivation. To have one’s field close to the homestead reduces time and labour input in working the field, and makes it much easier to guard the crops against birds, baboons and livestock. Many respondents told about how they had cleared new land after having moved their compound, i.e. it was a labour investment most found worthwhile. This has resulted in some areas having been almost completely abandoned, with settlement and cultivation now concentrated to two quite distinct zones (see fig. 6). Additional reasons why land in the eastern part of the village has been all but completely abandoned were presumably the erection of the private fence, and later of the veterinary cordon fence in the north and east. These effectively cut off the possibility of watering cattle in the Vukwi river, the only major water source in this part of the village. Cattle are used for ploughing, and also at other times of the year people prefer to keep them fairly close to the homestead, which is problematic without close access to water.

Surveys and reports discussing environmental change at national and district level emphasise the growing shortage of land for cultivation and grazing (Fortmann et al. 1983, Arntzen 1986, Asselman 1986, DTRP 1987). In many areas, especially close to towns and large villages, land pressure (and shortage) is undoubtedly a factor with important environmental implications. In Kalakamate, and possibly in other less densely populated areas, constraints connected with land shortage are different. Villagers in Kalakamate also complain of land shortage, but what is implied here is a wish for land which has been allowed to lie fallow for a suitable time, and which is situated at convenient walking distance from the homestead. The recent nucleation of settlement and fields has meant that land fulfilling these criteria is becoming scarce, a situation different from one where land with potential for cultivation actually does not exist. Differences in actual and perceived land shortage, in different areas or at different spatial scales, will have different implications for the local environment and for future land use.

A few major events at the local and national level deserve special attention. As described by Roe (1980), the colonial government set aside funds for water development, with the primary target of securing water for cattle. A colonial report from 1943 states that in the part of the native reserve to which Kalakamate belonged, the chief, aided by Government funds and local labour, had constructed one dam for the watering of cattle, and sunk three new wells through bedrock (Thornton 1943). Three years later, and referring specifically to Kalakamate (BNA S.238/7/1), it is described how both villagers and cattle use water from the rivers and streams during the wet season. When these dried up, usually at the end of June, there were plentiful wells, or pits, dug in the banks of the rivers and streams, which provided water. All in all the officer counted 17 wells in the village, dug by the people themselves, '[In this area] water is plentiful and stock are not driven long distances over the grazing ground.' (ibid.: 3). Villagers gave a similar description of the water situation in the past, and stated that water, at least for human consumption, was to be found in most years. However, water availability became even more secure after Independence, when a well was drilled and a dam constructed near the main settlement. This easy and secure access to water throughout the year, for both people and cattle, has influenced livelihood strategies, as well as land-use patterns and the environment.

Grazing practice, or rather the spatial pattern of grazing, has of course been affected by the changes in settlement pattern and water availability described above. Traditionally people grazed their cattle in and close to the village, but it was also common, at least among those with large herds, to keep some animals at remote cattle posts. However, most respondents stated that today, even if they could find trustworthy people to look after their animals, and afford to pay them, their herds are now too small to send any animals away. The location of homesteads and access to water have always been important for determining where cattle are to be grazed. The nucleation of settlements, and the location of the borehole and a dam nearby, has thus contributed to a concentration of cattle. The erection of private and veterinary fences has emphasised this even further. Previously cattle could move freely in all directions outside the village boundary, but now grazing opportunities to the north and east have been curtailed by outside intervention.

According to villagers, access to pasture has also been affected by regulations concerning the burning of grazing lands. In 1977 the Herbages Preservation Act (also termed Prevention of Fires Act) was laid down by the Government, as one of several laws intended to protect the range, including wildlife populations (Vegten 1979). The law states that nobody is allowed to burn grass in communal areas (Arntzen 1985). This, together with other regulations intended to preserve natural resources on communal land, is supposed to be enforced by institutions such as the Land Boards and the Agricultural Resource Boards. To a large extent this is, as yet, not an active part of their agenda, and in most areas there exists little control over management (Gulbrandsen 1984, Arntzen 1985). However, villagers in Kalakamate were well aware of this law, and claimed they adhere to it, in spite of its perceived negative impact on grass cover. It was stated that people hardly ever start fires any more, except when clearing a field, and that sometimes such fires may spread by mistake.

Concluding remarks on livelihood changes

Following the schematic presentation of components and processes of environmental change presented in figure 1, the present section has described changes within the social sphere which could be expected to have an impact on the environment. The importance of separating spatial scales has also been stressed. For example, population increase has occurred at all levels, from national to village, but the rate of increase varies, as does density distribution within any particular landscape. Livestock numbers have increased steadily at national and regional level. However, on communal lands in the former Tati Native Reserve, and more specifically within the study area itself, no trend is evident. Instead, drastic fluctuations caused by outside intervention, rainfall events and shifts in livelihood strategies seem to have been the norm. Agricultural practices have changed very little during this century, while the spatial pattern of cultivation and grazing has changed more.

During the colonial period what is now Botswana was characterised by a low rate of infrastructural investment. The peaceful transition to Independence in 1966, the discovery of diamonds, generous development aid and favourable trade agreements with Europe resulted in rapid changes which have had a marked impact on land use and environment. In Kalakamate, improvements in education, health care and infrastructure, as well as other changes in livelihood opportunities and strategies, follow district and national statistics, albeit at a slower pace than in urban areas (CSO 1994). Spatial distribution of settlements changed, contributing to other changes in land use. Villagers commented on how the diversification of income opportunities has reduced the dominant role of agriculture, livestock and other local natural resources in their lives, and also the knowledge and skills associated with the use of these resources. Modernisation of roads and transport, and a new spatial pattern of settlement, cultivation and grazing, have changed how people move through the landscape, further contributing to altering perceptions of the local environment.

MULTIPLE INTERPRETATIONS OF RAINFALL

After the above discussion of trends and events in the social sphere which have influenced livelihood strategies, land management and the environment, we now turn to a discussion of how rainfall pattern and events are perceived to have influenced these same components. In this semi-arid region, rainfall is characterised as low and extremely erratic, as a dominant driving force of ecosystem dynamics, and as having a major impact on the agricultural and pastoral aspects of livelihood strategies and therefore upon local land management strategies and decisions (Garanganga et al. 1994). However, farmers and scientists observe and measure the amount and distribution of rainfall in different ways, and they also often interpret the environmental impacts of rainfall variation differently. Views and explanations vary also among villagers and scientists themselves, and within both groups these change with time. This study reveals examples of consensus, as well as of contradictions. The latter are often more interesting, and an approach was adopted to explore the possibilities of a convergence of initially contradictory views.

The respondents, most of them farmers, described rainfall as the factor of overriding importance when explaining environmental change, and placed any discussion of their land management practices firmly within the context of rainfall. Similarly, range ecologists and others have long recognised that rainfall – along with environmental parameters such as soil type, and management practices such as burning and grazing pressure – is an important aspect of the ecosystem dynamics of semi-arid environments (Skarpe 1992). Until recently, most modelling of environmental change in semi-arid areas assumed a condition of equilibrium which depended on stable and predictable relationships between variables through time (e.g. when studying vegetation succession, carrying capacity and land degradation). By applying the ‘correct’ management practices, the dominant paradigm ran, carrying capacity could be sustained and the process of vegetation succession controlled to suit a particular set of management objectives (see discussion in Abel and Blaikie 1989). Traditionally, certain environmental changes such as bush encroachment, a decrease of grass cover or specific changes in species composition, were seen as sufficient indicators that the land was being mismanaged and degrading (e.g. Walter 1985).

Over the past ten to twenty years, many of these assumptions have been re-evaluated, and a new understanding of semi-arid ecosystem dynamics is gaining ground, where outcomes at particular points in time and space are seen as the results of particular events, such as drought (Behnke et al. 1993). This approach has been found to be especially valid in areas characterised by low average annual rainfall and high inter-annual variation (Shepherd and Caughley 1987, Ellis and Swift 1988). Here, climatic variability (such as rainfall fluctuations and perturbations through drought) are seen to be the main factors controlling plant biomass, livestock numbers and human strategies for exploiting the environment (Ellis et al. 1993, Scoones 1995). The concept of long-term equilibrium, broken only by human management practices, has been replaced by one where a non-equilibrium dynamic is identified as an inherent driving force of these ecological systems. Although much of the ecological theory behind this paradigm-shift is not new (see e.g. Holling 1973), its application to semi-arid rangelands is quite recent. This has come about through a re-examination of physical data, partly through the recognition of the unsatisfactory predictive performance of equilibrium type modelling (e.g. Westoby et al. 1989), and partly through a wider recognition of indigenous knowledge systems and practices – and perhaps most importantly, the rather poor record of range management initiatives (see e.g. Sandford 1983, Behnke et al. 1993).

Farmers' recollections

Villagers and scientists agree on the importance of rainfall amount and variability. However, agreement about a local chronology of rainfall events, including long-term patterns of change, is often – but not surprisingly – lacking. Almost all villagers claimed that rainfall has declined since their youth. It was stated that 'before', rainfall varied less between years, and annual amounts were, on average, much higher than at present. Most said that random variation, between and within years, has always been the main characteristic of rainfall, but stressed that underlying this a downward trend had occurred, '...droughts have become more common', '...but the heaviest rains fell in the 1940s', and '...the rain has become more unreliable than before'. This perceived decline was also illustrated and substantiated by descriptions of primary and secondary effects on natural resources and land use, and by evidence of changes in moisture availability (see table 4).

Initially many stated there were no droughts in 'the old days', but would later recount stories told by their parents and grandparents, of droughts so bad that '...people had to eat the skins of animals', and 'there was one drought that was extremely bad and it was called "don't ask me"'. In their construction of a rainfall chronology, hardships experienced during droughts in the '40s, '60s, '70s, '80s and '90s were described. Some years were described as bad by all, e.g. the extreme drought in 1946/47, while other drought events were only remembered by some. The perception of an overall decline in rainfall was not shared by all respondents, there were a few who denied the existence of any trend, 'This is the way it has always been; some years we get enough rainfall, whereas other years there is too little or none'. It is the view of these few informants which is in accordance with official rainfall records.

Official records

The use of official rainfall records poses several problems. With rainfall variation in space in any one year being extremely high, it is important to use data recorded as near the study area as possible. On the other hand, reliability and long time series are equally important. In Botswana only a few stations have recorded rainfall since the beginning of this century, and it is these records that are most reliable and complete (Department of Meteorological Services, Gaborone). For the study area, Francistown is the nearest such station, situated 66 km from Kalakamate. Records from rain gauges located closer to Kalakamate go back only to the late 1950s or later, and contain gaps in the data of months and even years. In Sebina, located 26 km from Kalakamate (and 48 km from Francistown, see fig. 2), rainfall has been recorded since 1958/59, and these records are almost complete. In figure 7 (a–d) and table 3 these data are compared with those from Francistown.

In Botswana the rainy season covers the period October to April, with very little rain falling in the remaining months. Therefore, throughout this study, rainfall is presented and compared as annual rainfall by hydrological year, i.e. July–June. When discussing effects of rainfall variation on crops, pasture and other natural resources the intra-annual distribution of rainfall is extremely important (Vossen 1987). This is discussed further later on. The comparison between Sebina and Francistown in figure 7 is therefore given for annual totals and separately for the periods of early, mid and late rainy season.

In table 3, the median, mean, and coefficient of variation (CV) of annual rainfall for Sebina and Francistown are presented. For Francistown these values are given for the periods 1922/23–1993/94 and 1958/59–1993/94 respectively. These values indicate that the average rainfall has been almost identical, with a slightly smaller spread for Sebina. Figure 7 shows that, considering the high inter-annual variability of rainfall, there is a reasonable correlation between the rainfall data from the two locations. (It may be noted that during the last 20 years the agreement has been better. The difference has been less than 10% in 10 years, and 10–20% in 8 years. However, in the recent dry years 1991/92 and 1993/94 the difference was great, with very low values from Sebina. Also, there are considerable local variations in the intra-annual rainfall distribution, as seen in figure 7.) Although it is recognised that local rainfall on a daily, and sometimes even monthly, basis will often deviate from data recorded at a nearby location, the comparisons presented here show that for longer periods the general pattern of variation is comparable between these particular stations. Thus, for the purpose of this study it was considered most appropriate to use rainfall records

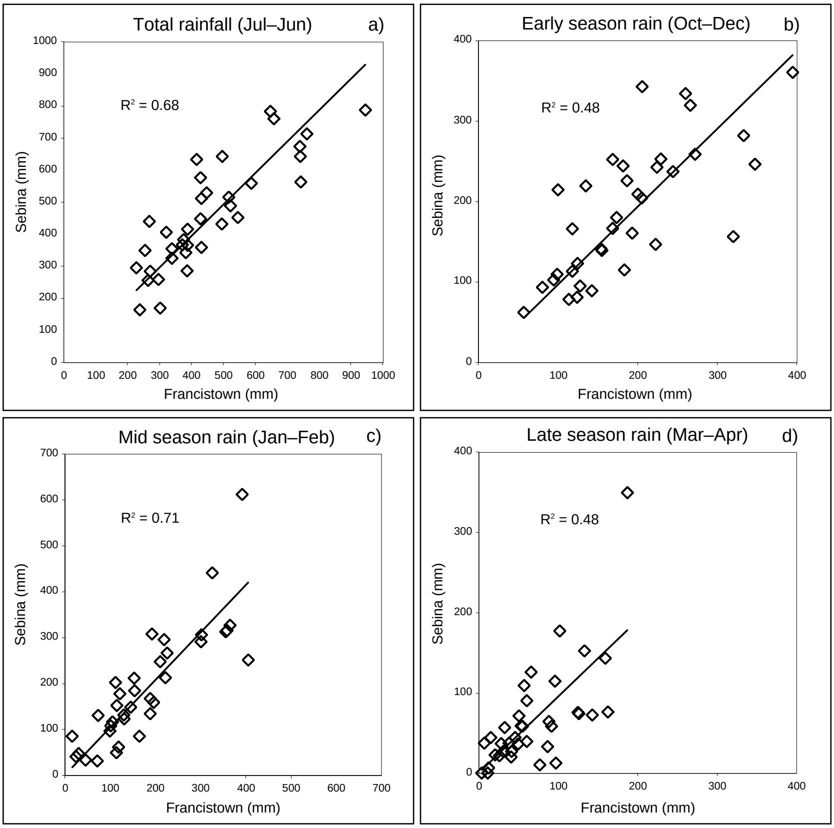

FIGURE 7 a–d. Correlation of rainfall recorded at Sebina and Francistown for the period 1958/59 to 1993/94

	Francistown 1922/23–1993/94	**Francistown 1958/59–1993/94**	**Sebina 1958/59–1993/94**
Median (mm)	426.4	423.4	435.3
Mean (mm)	458.4	456.2	458.5
CV (%)	39	38	37

TABLE 3. Median, mean and coefficient of variation (CV, i.e. standard deviation/mean) of annual rainfall at Sebina and Francistown

Annual rainfall is measured by hydrological year July–June.

from Francistown, since they cover a longer time and can be expected to be more reliable.

In figure 8 annual rainfall data from Francistown for the period 1922/23–1993/94 are presented in more detail. The intra-annual distribution is shown by dividing the rainy season into early (Oct–Dec), mid (Jan–Feb) and late (Mar–Apr) rainy season, and adding the rainfall before and after the rainy season at either end of the bars.

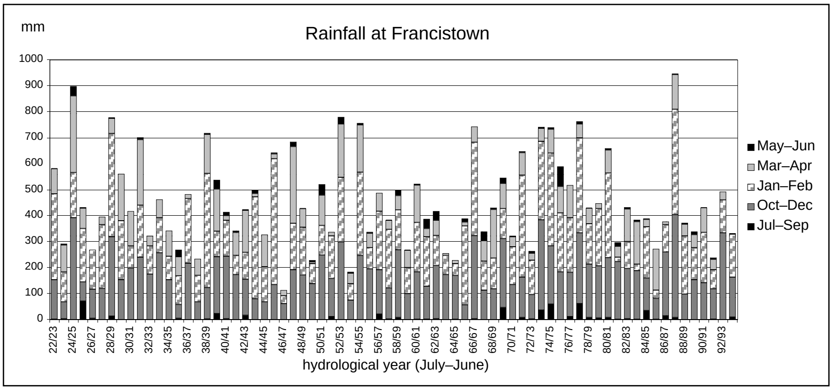

FIGURE 8. Annual rainfall (July–June) and intra-annual distribution of rainfall at Francistown for the period 1922/23–1993/94

The grey-scale codes for periods Jul–Sep and May–Jun are the same.

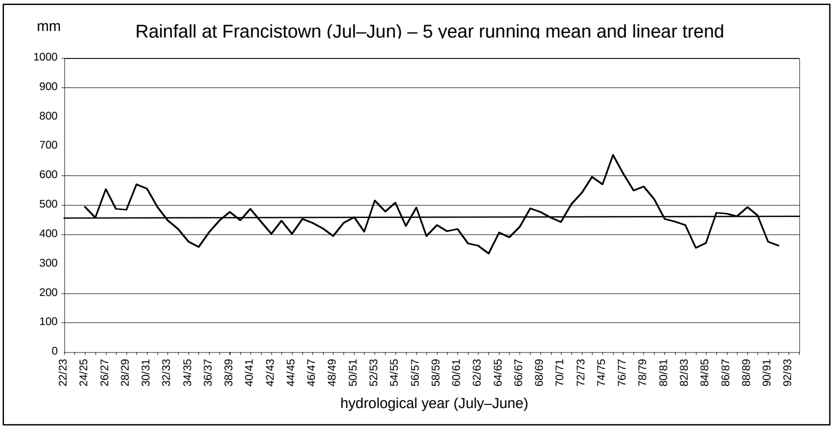

FIGURE 9. Five year running mean (centred) and linear trend of annual rainfall for Francistown 1922/23–1993/94

Figure 9 shows the five year running mean of annual rainfall for the same period, with the calculated linear trend. The data from Francistown are in accordance with regional studies, where statistical analyses of rainfall records for the last hundred years and more have shown no trend of declining, or increasing, annual rainfall in Southern Africa (Lindesay and Vogel 1990). Instead a cyclic pattern of rainfall fluctuations, with a quasi-oscillation of 18 years between alternating wet and dry decades, is indicated (Tyson 1986). Existing rainfall records for Botswana, dating back to the early 1900s, show the same pattern, especially for the eastern part of the country (Tyson 1979, Bhalotra 1985). However, it should be noted that within the cycles, a high random variation occurs on a seasonal and annual basis (Tyson 1986).

Dealing with contradictions: a method towards achieving closure

The assessments of rainfall variation over time presented above are contradictory on several counts, both when comparing farmers' views with official records, and when comparing perceptions among the respondents. To resolve these contradictions completely, more data would be needed. The high spatial variability of rainfall calls for precipitation measurements from the study area, and even from different locations within this area. Verification of the change in moisture availability and its effects as described by farmers would necessitate records of local physical and socio-economic parameters. Lacking these, a methodology towards achieving closure (i.e. a single and most credible intrepretation) must build on a discussion of socio-environmental relationships, in the context of what the stated observations of rainfall really measure. (See also Leach et al. 1997, for a review and critique of different approaches to contested and diverse interpretations of environmental change.)

While scientists measure rainfall as an exact amount at a specific place and time, to local farmers rainfall, and its variation over time and space, is perceived in relation to what it can afford them, i.e. what the effects of rainfall are for them in terms of their livelihood strategy. The impact of rainfall is evaluated for each particular set of socio-economic circumstances, i.e. in relation to a particular livelihood opportunity, or rather to the specific livelihood strategy that an individual can manage at a particular point in time. In addition, we suspect that rainfall is often used as a metaphor for a general change in livelihood circumstances. Thus, a statement of declining rainfall may not primarily reflect a particular environmental change, but instead a feeling of regret for 'the good old days'. This is especially likely when the respondents are older people, who have lived through dramatic socio-economic and political upheavals. This is the **first** possibility for explaining contradictions between the local and the official – local people think that they are stating empirical facts, but they are not, and scientific and official versions must be the arbiter for discovering the truth. Certainly it is problematic to gauge to what extent local people are wrong, and it brings up a number of post-modern challenges over representation, authorship and the privileging of knowledge claims (Rosenau 1992).

Put simply, we all invent narratives, which are our own versions of a complex reality, and our cultural and professional repertoire is usually well stocked with them. Their function is partly to reduce uncertainty and ambivalence, which often necessitates that reality is simplified, e.g. through a reduction of influencing factors and interdependences. Usually, the authors' unstated agenda is to work out an acceptable version of their own relations to the subject matter, and therefore explicitly or implicitly put themselves into the narrative. The other important aspect of narratives is that they are repeated over and over again, becoming stereotypes and formulas for coping with contradictions, uncertainty, and a state of flux. They are also adapted to the views of others and to external events, and although they form a stable set of assumptions, they are seldom static.

Older people the world over have their own narratives, so much so that the narratives often become the stereotype by which their authors are perceived. Older people in Botswana are no exception, as they try to make sense of their ageing and their changing relationships to family and wider society. The 'good old days' is one typical narrative, and the 'ignorance or fecklessness of youth' is another. Both appear in older people's versions of the environmental history of Kalakamate. However, here we treat informants' accounts as both narrative and as a version of a shared truth about the environment. Thus, when most respondents say that rainfall has declined, this might be expected – that is what they would say. The next step is not to dismiss their accounts with incredulity and attribute them merely to a narrative of ageing and change, but to check them with other narratives, including scientific ones. This would include the adaptation of narratives said to describe longer periods to recent events and short-term 'trends'. For example, in this particular case it must be stressed that the interviews took place after a period of over a decade characterised by droughts (see fig. 8). Furthermore, this period had followed on a decade with several years of above average rainfall. Although efforts were made during the interviews to avoid such biases, the low rainfall experienced over the last 15 years is likely to have influenced perceptions of long-term changes.

While the first possibility refers to what may be called imperfect storage of observational data, a **second** possibility is that the changes perceived are due to the informant (or the researcher) not fully realising the influence of differences in 'measuring conditions' then and now. With different measuring conditions we mean for instance that observations 'then' were governed by the interests, needs and capabilities of a young person, while observations 'now' are those of an old person. Apart from age, several other factors which influence an individual's perception may also change with time, e.g. where in the village the person lives and moves, as well as family conditions and wealth. These are important aspects in the assessment of most, if not all, information obtained in an interview-survey about change.

We now turn to other explanations which are based upon the premise, not that one version is right and the other wrong or inaccurate, but that each group of 'observers' is experiencing different aspects of a real environment and and/or valuing their importance differently. Many villagers state that average annual rainfall has declined, while official records show no such trend. For explaining such contradictory experiences, a **third** possibility is that rainfall actually has declined in Kalakamate. That is, an environmental (or social) variable is observed in several places (or at several times), and it is wrongly taken for granted that the data represent the same reality. However, it is very unlikely that rainfall in a particular village should deviate essentially from the overall pattern of the region, and thus the following discussion is based on the assumption that average annual rainfall has not decreased in Kalakamate. It should be noted that for several other socio-environmental variables mistaken generalisations of this kind are common.

A **fourth** possibility is that the internal dynamics of the environmental variables studied have changed in a way that affects the farmers perception and experience, but not the apparently contradictory scientific measurements considered. For rainfall, it could be that the intra-annual distribution pattern has changed. It is well documented that distribution of rainfall within the rainy season varies between years (Bhalotra 1985, 1987). Thus, over the year, for different areas and for different purposes of land use, available moisture may differ dramatically between years with similar annual rainfall. Vossen (1987) found that the correlation between annual rainfall and cattle and crop performance improved substantially when the rainy season is divided into three sub-seasons. Early and late season rainfall, which have a strong influence on the biomass of grass and browse available during the dry season, are more important for livestock survival than mid-season rainfall. Crop yields show a strong correlation with total seasonal rainfall, since farmers will shift the planting period and the crops and/or soils chosen depending on how rainfall fluctuates. However, the mid-season rainfall is a period of crucial importance, since in a year with poor early rains farmers rely on being able to plant in January, while in a year when early rainfall is good, crops will reach the stage with the highest water requirements during the mid rainy season (Vossen 1987).

Rainfall records from Francistown for 1922/23–1993/94 were analysed for a possible trend of early, mid and late rainy season rainfall respectively. In figure 10 (a–c) the five year running mean for these periods is shown along with the linear trend. These data show a slightly confusing picture since they indicate that early rainfall has increased, while mid season rainfall has remained virtually the same, and late season rainfall has declined. If anything, the situation for crops has improved, while grass cover may be expected to be depleted earlier in the dry season, but then regenerate quicker the following rainy season. Considering the high year to year variation for all these sub-seasons it is doubtful whether the indicated (but slight) trends are reflected in any long-term changes of the

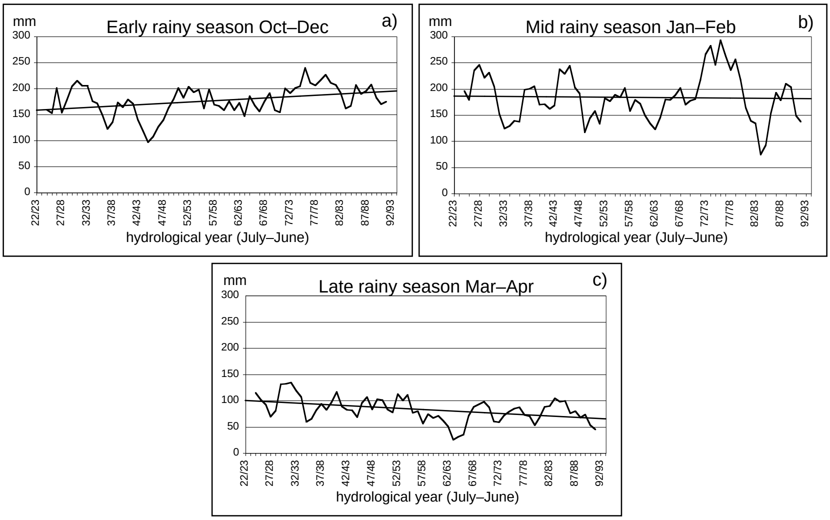

FIGURE 10 a–c. Five year running mean and linear trend for early, mid and late season rainfall for Francistown 1922/23–1993/94

environment; also the spatial variation between Francistown and Sebina is large enough to allow quite different slight trends at Kalakamate.

Annual precipitation, intra-annual distribution and variation over time are some characteristics of rainfall which affect the environment. Many other rainfall characteristics, e.g. intensity of rainfall, length of dry spells and when in the year they occur, are also important. Added to these are the synergistic effects of different rainfall characteristics acting together with other climatic variables, such as temperature (Jackson 1989). An in-depth study of all these factors is not within the scope of this study, and thus we cannot state with certainty that there has not been a change in some aspect of rainfall. However, had a measurable such change occurred, with an environmental effect akin to that of an overall decline in rainfall, we assume that it would have been reported in the studies consulted. Thus, we find it highly unlikely that the farmers' perception of declining rainfall is due to a permanent shift in rainfall pattern or characteristics.

A **fifth** possibility is that, while rainfall characteristics (and several other environmental factors) probably have not changed significantly over the past seventy years, livelihood strategies and patterns of land management have. Thus, rainfall may have declined when seen in relation to its relative sufficiency for an altered set of requirements. This possibility is examined in relation to the impact the nucleation of settlements, the fencing of the private ranch, and the erection of the cordon fence has had on the location of fields. As shown in figure 6, fields are now concentrated around the kgotla (the 'chief's place'), and the other nucleated settlement areas to the south. The key characteristic to be examined here is the possible change in produce output, especially in terms of yields, that may be interpreted as an effect of a decline in rainfall. We will discuss the possible decline in yields as an effect of changes in available moisture and/or a reduction in soil fertility, and we hypothesise that the change in the general location of fields has had a negative impact on these parameters for individual households. An increased competition for land in a particular area may force households to clear land which has been rested for an insufficient time, to make do with a soil type less suitable for cultivation than those previously ploughed, or it may constitute one reason for continuous cultivation of the same field in spite of a foreseeable or experienced fertility decline.

Looking first at possible changes in moisture availability, this is important to the farmer in terms of its effect on such resources as crops, grass, browse and fruits, as well as on the amount of water in wells and rivers. This fits the scientific understanding which states that it is the amount of moisture available to plants and animals which is of direct environmental, and therefore agricultural, importance (Huntley 1982). This, in turn, depends on many factors, e.g. evaporation, transpiration, deep percolation (Bate et al. 1982), and the balance between infiltration and storage in the soil (Stafford Smith and Pickup 1993).

Infiltration and storage depend on the texture and consistency of the soil, surface sealing, a presence or absence of a pan horizon, distance of this horizon from the surface, salinity and micro- and macrorelief characteristics (Tinley 1982, Casenave and Valentin 1992). Concerning soil storage of water, Biot (1988) found that this is largely a function of soil depth and the capacity of the soil to retain water per unit volume. In addition, other physical variables such as vegetation cover and type of plant community play an important role in determining the distribution of surface, soil, and ground-water. Thus, the variability over space and time of a multitude of environmental variables affect moisture availability. On the whole, farmers are aware of this, and their observations were found to constitute an important element in their descriptions of rainfall variation through time.

Farmers' awareness of different relationships between the biotic and abiotic are often expressed in their land management decisions. For example, the considerations behind a farmer's choice of where to locate a new field include, among many others, locally recognised relationships between different types of soils and crops under conditions of varying rainfall. If other factors, e.g. distance between field and settlement, are disregarded, most farmers said the best location of a field is one with at least two different soil types, which is illustrated in box 1 (numbers within brackets in the following text refer to the number of a particular quotation in a box).

Farmers express preferences about which crops to plant on what soil type (1, 2), as well as strategies concerning which soil type to plough and plant depending on actual and predicted rainfall distribution in any particular year (3, 4, 5).

1 ‘Motlhabana soil [light red, sandy]* can produce better crops of groundnuts and monkey nuts than the mokata soil [red, sandy loam].’

2 ‘Red corn grows well on mokwakwa soil [light grey, some clay]. This is the only crop that does well on this soil, but only if rainfall is not too low.’

3 ‘Motlhabana soil [light red, sandy] is good when there is little rain – but when there is too much rain the crops sink in this soil. Mokwakwa soil [light grey, some clay] gets dry when there is little rain, but it is good when there is much rain. We have these two soils in our field.’

4 ‘When the rains are late, or rainfall is very low at the beginning of the season, then we only cultivate the part of the field that has mokata soil [red, sandy loam]. The other half of the field is more rich in clay, and this is too hard to plough if it is dry. However, if there is enough rain this soil will produce a good harvest.’

5 ‘When choosing land for a new field you look at the soil and the vegetation, which will tell you if a good crop can be had from that land. The presence of many mokoba [*Acacia nigrescens*] and modumela [*Kirkia acuminata*] trees tells you that there is enough water available. The best soil is loam with some sand, red in colour [mokata] – on this soil you can get all kinds of crops.’

* Throughout the paper all local soil names are given in Setswana.

BOX 1.

Although a loamy soil is, overall, considered best, specific crops are said to do better in sandier soils, and although clay-rich soils are the most productive under beneficial circumstances, most respondents stated that access to a sandier soil was vital, since it will produce at least some yield even in years with low rainfall. Loamy soils have a higher water holding capacity than sandy ones, but the fact that sandy soils have low water retention may result in a better crop response under dry conditions with scattered rain showers, as compared to a soil with a higher clay content (Radcliffe 1990, Walker 1993).

Although a detailed soil survey would have been preferable, some information as to soil differences within the study area can be gleaned from the maps of geology (scale 1:125 000), soils and land suitability (1:250 000) produced for the area (Botswana 1975, 1984, 1989, Litherland 1975, Radcliffe 1990; and see Dahlberg 1995 for Kalakamate specifically). It should be noted that the maps of soils and geology only list the order of dominance of different soils and rocks for different units, recognising that the spatial variation is much larger than what can be shown on the maps. This is especially true in the study area where numerous occurrences of basic rock cause marked variations in soil quality.

The land around the main settlement in the north-west is dominated by acidic rocks (granite and gneiss) and soils are mainly regosols. In the eastern corner and in the southern half of the area dolerite intrusions and basic and ultrabasic rocks (e.g. serpentinite and amphibolite) are quite common, and soil types are more varied, with regosols, luvisols, leptosols, cambisols and vertisols occurring in a patch-like manner. Regosols are shallow coarse sands to loamy sands with much gravel and stone in the topsoil, and due to their extremely low waterholding capacity are prone to crop failure especially in years when rain fails at the peak of the growing season, and even in good rainfall years large yields cannot be expected (Radcliffe 1990). The higher content of fine sand, silt and clay found in the other soil types indicate better water holding capacity, although most of these soils are also characterised as poor.

On the land suitability map (Botswana 1989), where expected output of rainfed cultivation of sorghum has been the main ground of classification, the whole of Kalakamate falls under the categories 'marginally suitable' and 'permanently unsuitable'. The authors acknowledge that in spite of this rating 'traditional rainfed cropping is, in fact, commonly practised [in the area]' (Radcliffe 1990: 54), and stress the fact that the evaluation is related to an assumed average set of conditions, and that the results 'do not indicate the chances of success or failure associated with cropping [each] land unit' (loc.cit.) under conditions of fluctuating moisture availability. However, the land suitability map shows that although almost all land in Kalakamate is classified as 'permanently unsuitable', the area designated as slightly better is located in the southern part of the village, far from the main settlement. It should be noted that a large part of this 'better' land is taken up by heavy clay soils, which in most years are either too hard or too muddy to plough.

The maps of soils and geology also give some indication as to where soils with a slightly better nutrient content may be found. Soil derived from acidic rock can be expected to have lower nutrient levels than those from basic and ultrabasic parent material. Thus, the likelihood of finding soils with a higher nutrient content would increase as one moves to the east and south. However, many factors influence soil fertility, and past land use is among the most important. Respondents were asked what would cause them to abandon cultivated land, and a decline of soil fertility was very seldom given as a direct reason. A field ploughed for a long time was said to become 'old', and signs of this were that yields decreased, top soil was washed away, and most importantly that the field would become infested by troublesome weeds, especially the grass motlhwa (*Cynodon dactylon*).

This grass is a hardy perennial pioneer which colonises bare ground, is tolerant to drought, fire and grazing, and, once established, spreads rapidly (Skerman and Riveros 1989). Such infestation was described as a common reason to clear new land. When asked specifically about soil fertility, some respondents said that the occurrence of motlhwa in a field was a sign of nutrient depletion, while most simply stated that the weed 'will win over the crops' and yields decline. This grass is common in Botswana, and often occurs in dense swards which suppress the growth of crops (Phillips 1991). Farmers described how on recently cleared land, which previous to clearing had been rested for a long time, weeds were not a serious problem, and motlhwa was seldom encountered. However, after cultivating the same land for some time the field would gradually become infested by motlhwa. When this happened, farmers would gradually abandon the parts of the field where motlhwa appeared, increasing the field in another direction, until finally it was time to clear a whole new field. When this was not possible, due to land and/or labour shortage, the farmers would plough and plant in spite of the weeds, or make do with a smaller field. This general description was substantiated by a number of histories of fields for individual households and families, which often could be corroborated in the aerial photographs.

In most cases mentioned in the interviews, a move of settlement led to the clearing of a new field, even if this meant leaving still fertile land and, in some cases, having to cultivate on a less preferred soil type, ‘My parents’ field was on motlhabana soil [sandy], and this is better for crops than what I have now which is seloko soil [heavy clay]. We chose the present field because it is close to the house’. Only in a few cases did respondents actually state that they had ended up with less fertile soils, but many complained about the increasing shortage of so called ‘virgin’ land (i.e. land that had been rested long enough). With more households competing for land in the same area it is very likely that the scope for ‘a best choice’ has become more limited.

Furthermore, the preference for having easy access to water and other services is one reason why people in the future may be less inclined to abandon their fields because of erosion or weed infestation. In addition, the practice of wire-fencing one’s field, which with favourable government loans is becoming increasingly common, may have a similar effect. Respondents were very positive towards such fencing, since it more securely keeps livestock away from the growing crops, but it may also lessen the incentive to allow for fallow periods. This generalised picture does not give any definite verification of our hypothesis. However, it does suggest that the possibility of acquiring fields on soils where productivity could be expected to be higher has been reduced as people have become concentrated in a limited area. It also suggests that, at least at present, people may be more ready to accept a decline in yields, rather than locating their field or compound further away from the nucleated settlement areas.

We shall now look into other aspects of changing farming practice and strategies, in a broader examination of the possibility that local interpretations of change are structured in relation to differences between informants, as individuals or as members of different groups. This is our **sixth** possibility of explanation of contradictions. Characteristics such as age, gender and wealth throw some light on the, often contradictory, interpretations of changes over time. Respondents perceive drought periods differently, and therefore remember them differently depending on these and other characteristics. The influence of wealth is the most obvious, and must be included also when responses are compared by age and gender. For example, if a household’s herd is large, the loss of a few animals is not so serious as if it only had a few head of cattle to start with.

If the animals are in poor condition following a drought, the household may still manage to get the field ploughed if there is money to rent a tractor. Other characteristics being equal, a woman (particularly one without other sources of income) may experience a drought harder than a man, since it is she who usually is responsible for feeding the family, while it is the man who has more easy access to outside income (Hesselberg 1993).

The quotations in box 2 illustrate some of the socio-economic circumstances which influence the individual's perception of rainfall. Amount, distribution and variability of rainfall will have a different impact on people depending on the particular period in the socio-economic history of a community (6), and on the particular period in the life-cycle of a household or individual (7). That is, at any point in time differences in livelihood opportunities will shape the individual's, and/or the community's, interpretation of changes in available moisture (6, 7, 8).

6 'Before, a drought would affect people more, since they could not buy food – therefore 1937 and 1947 were the worst drought years.' *(man born in 1912)*

7 'I would not have cared so much about the earlier droughts, since I did not have any cattle to lose then.' *(man born in 1927)*

8 'Before, the people used to be free, but now they are starving. Now people have to buy food if the harvest fails, so if you do not have money you will starve. Before people would keep reserve food in their granaries, then they were not forced to buy anything. The head of the family would keep the granary and distribute grain in times of drought.' *(woman born in 1908)*

BOX 2.

Risk reduction is another important aspect of livelihood strategies. In Kalakamate, local management of natural resources is adapted to the erratic variation of rainfall, and also to meeting socio-economic shifts. In an unpredictable physical and social environment, strategies of risk avoidance are the norm. Perception of rainfall variation will depend largely on how well different risk avoidance strategies can be put into effect, and this will vary between people and over time. A dry year may not be perceived so negatively if the farmer has been able to implement successful risk-reducing strategies. For example, in the growing season of 1993/94 there was some rainfall in November and December, slightly better conditions in January and February, whereafter not a drop fell until next December. As demonstrated by the quotes in box 3, farmers who had early access to draught power could successfully practice a strategy of early ploughing, and look forward to a fair harvest (9, 10), while those who could not described 1993/94 as a dry or bad year (11, 12).

9 ‘At times, e.g. this year *[1993/94]*, there is rain, at least here in Kalakamate.’

10 ‘This year *[1993/94]* we got nearly as much rain as when I was young, but it stopped in the middle.’

11 ‘This year *[1993/94]* we were not able to plough the whole field because we were sharing a span of cattle with many other people. We do not have any of our own. And before it was our turn the cattle had to be vaccinated after which they have to be kept aside for two weeks, and after that it was too late to plough.’

12 ‘This year *[1993/94]* is a drought year, I cannot think of any year that has been drier than this.’

BOX 3.

However, it should be noted that individual experiences of good and bad years may also be caused by the high variability of rainfall over very small distances (Jackson 1989). In the same year, fields in one part of the village can receive, for example, above average rainfall, while those in another part receive much less. The extremely local nature of rain showers also means that a scattered distribution of fields, within an extended family or the village as a whole, would be a strategy of decreasing the risk of wide-spread crop failure.

Alternative interpretations of a perceived decline in rainfall

In tying together the different threads presented above, the point of departure will be the respondents’ own words. Those who claimed that rainfall had declined were asked how they could be sure of this, and apart from direct statements, a range of evidence was presented, in addition to perceived primary and secondary effects. A selection of these answers is listed in table 4, and these are analysed in the context of the relationships between rainfall, moisture availability, livelihood strategies and land management practices discussed above.

The first statements, about droughts and the reliability of rainfall, are not accurate in a scientific sense, but they may well be a reality for these particular respondents. Rainfall intensity has not been measured in the past, but an analysis of the number and distribution of rainfall days shows no trend. However, if soil characteristics and vegetative cover have changed, then a change in the rate of runoff and infiltration is likely to follow. This would create a different situation in terms of plant growth, erosion and hydrology, even if rainfall intensity is the same. In other words, different causes can create similar effects.

Several people claimed that ‘the harvests were larger before’, i.e. comparing those of their childhood and youth with the present. Others refuted this, saying

Direct statements
Before, there were fewer droughts
Before, the rain was more reliable
Before, the rains were heavier
Primary effects
Before, people got bigger harvests
Before, there was plenty of fruit
Before, not so many cattle died
Secondary effects
Before, people made the effort to plough
Before, people had granaries
Before, the land would recover faster after a drought
Evidence
Before, there was water running all over the ground
Before, you could not take the car off the road, it would sink
Before, there was more water in the rivers
Before, there were more springs with water
Before, the watertable in the borehole was higher

TABLE 4. Changes attributed to declining rainfall

that a good rainfall year in recent times (e.g. 1987/88) gave as large a harvest as in a good year when they were young. One factor directly related to yield is the kinds of crops grown. The interviews revealed that very little had changed in this respect. All respondents maintained that they plant the same crops as their parents did, except tobacco and dagga. A few new varieties of maize, sorghum and beans had been introduced over the last decades, but these had not replaced the previously used varieties. A farmer decides which crops and varieties to plant in a particular year, or on a particular part of the field, depending on realised and expected rainfall. Many mentioned that access to new varieties had increased the possibility of a good harvest. However, the harvest will vary between farmers in one year, and for the same farmer between years, leading to different perceptions of rainfall in relation to harvest in any particular year.

Of course, a decline in harvest can be caused by many factors, such as a decrease in soil fertility, in available labour and draught power, in manure and viable seeds, or an increase of soil erosion. Initially, few said they had observed any signs of soil erosion, but upon further discussion almost 70 percent said that in their field some soil was being washed away. Farmers stated that, apart from ploughing along the contours, there was little that could be done to stop erosion, but then, very few saw it as a significant problem. If the field is on sloping land soil will be washed away, 'but it is not a threat to the lifetime of a field', and only one or two farmers made any connection to declining yields. In the study area most land is flat or gently sloping, and neither aerial photographs nor fieldwalks gave any indications of severe erosion in fields. What was, however, seen as a threat to the harvest was the infestation of the weed motlhwa (*Cynodon dactylon*). Depending on the magnitude of infestation, yields of the same crop will vary from field to field in the same year.

Farmers did not recognise fallow periods as part of their cultivation practice, but in reality it is included in their management of the land, since people would shift the location of their fields when weeds became too troublesome, or when grazing became scarce. It would seem, however, that these periods of resting the soil may already occur less frequently, and be of shorter duration. Increased competition for farming land in certain parts of the village will make people less inclined to abandon cleared land. It was described how farmers now deal with weeds by manual weeding, by an extra ploughing in the winter, or by 'planting on top of the weeds, even though this gives a lower harvest'. The erection of proper wire fences around the fields may further reduce farmers' willingness to abandon an old field. However, as discussed below, outside incomes have meant that many families are less inclined to plough and plant every year, which could result in more frequent short fallow periods.

As we have shown, the availability of grazing and farming land has also become cumulatively more restricted. The establishment of a private ranch has sharply reduced grazing and agricultural land to the east and southeast; the nucleation of settlements has resulted in people leaving the outlying areas; and the veterinary fence has curtailed movement to the north and north-east. Not only are people forced to cultivate the same land for a longer time, there is also less choice in available land, 'Things are not equal [to how they were before], and so you cannot simply compare harvests'.

The size of harvests, as well as of livestock herds, is also related to availability of labour. Many of the old people in this study remember a time when cultivation and livestock rearing involved the whole extended family. Today most young children attend school, either locally or as boarders with relatives in a larger village or town, and therefore take less part in such activities as herding, weeding, guarding the field and collecting wild produce. Many of the respondents' children who were beyond school-age have moved away to earn a living in Francistown or in other towns and large villages in Botswana. Lack of labour due to migration was mentioned as one reason for temporarily, or even permanently, abandoning a field. Several respondents complained that their children were not interested in agriculture, and that the whole culture of helping family and neighbours was disappearing. As mentioned above, this is a typical stereotype narrative about the 'young generation', but in Botswana the educational and economic development since Independence has in fact resulted in young people seeking a future in other venues than traditional farming.

The statement 'before, [in the past] people made the effort to plough' is explained by villagers in many different ways. Although a decline in rainfall is principally identified as the reason for this lack of action, there are others too.

Irrespective of a real change in rainfall, or of other factors affecting agricultural productivity, for most households an increase in prosperity is seen to lie in activities other than agriculture. In the period 1930 to 1960 remittances from the men working in South Africa were mainly invested in cattle, or kept as a safeguard for drought years. Today money pays for education, travel, housing, household goods and an increased dependence on imported foods. Although it is still important to retain access to agricultural land, and land and livestock act as security measures, wages and government subsidies, including drought relief, are replacing the role previously played by the village and household granary. Other changes perceived as primary effects of declining rainfall, e.g. in the abundance of natural produce such as grass, firewood and fruit, are discussed in Dahlberg (1996, III, section 7).

Some villagers suggested direct visible evidence of a decline in rainfall, claiming that the amount of surface and ground water had declined. However, many respondents denied this, describing how the amount of water in rivers and streams has always varied within and between years, and that this general pattern of variation has not changed. Whether the streamflow has changed or not is very difficult to ascertain. Changes in vegetation and soils could cause a change even if rainfall remains the same, and such effects may explain claims that certain small streams have dried up. The drying up of springs described by some can also have been caused by local environmental changes. It is also conceivable that the reduced dependence on surface water for people and cattle, since the borehole was drilled, has meant that people no longer are as aware of fluctuations in ground and surface water. Some people complained that the pits dug in the streambanks contain less water now, but several respondents offered alternative explanations: ‘Now we prefer to go to the tank for water, so no one bothers to keep the pit free from sand that has been washed in. If this sand was removed perhaps there would be as much water there again’.

Concluding remarks on rainfall

Before going on to summarise the whole paper we can list the following tentative conclusions about rainfall trends in Kalakamate:

- i Farmers’ descriptions of environmental change during their lifetime are, in a majority of cases, dominated by a perception of a decline in average annual rainfall, and this belief is used to explain changes in a multitude of environmental and social parameters.
- ii According to official records average annual rainfall has not declined.
- iii Changes in other rainfall characteristics, likely to have had an effect similar to that of an overall decline in rainfall, have not been identified.

iv We suggest that farmers' perceptions of declining rainfall is instead explained by, on the one hand, changes of other physical parameters such as moisture availability, soil fertility and vegetative cover; and on the other hand, different and changing livelihood opportunities and strategies. In some cases change has resulted in reduced options for utilising rainfall and for avoiding the risk of moisture shortage. In other cases the change is in the increased range of choices in livelihood opportunities outside agriculture.

v Accurate descriptions of past climatic change, in relation to its impact on livelihoods and land-use strategies, are desirable for an understanding of the present and predictions for the future, but difficult to collect without lengthy narrative and (sometimes) speculative interpretation.

vi There is some evidence that, because of the nucleation of settlement pattern and the exclusion of other potential agricultural land through privatisation, cultivation now takes place more often on soils which give poorer yields.

Three of the four components in the diagram of relationships of relevance to environmental change (fig. 1) have been discussed in some detail in this paper. Trends and events at the national, district and village level have been related to their effects on livelihood strategies and land management. The fourth component in the diagram (environmental outcomes) has been described and discussed more briefly. For details about observed and perceived changes in such environmental features as the cover, density and species composition of the woody vegetation and grasses respectively, and in the abundance and availability of firewood, fruits and thatching grass, see Dahlberg (1996, III, section 7).

SUMMARY AND CONCLUSIONS

Numerous changes have occurred in the social and environmental sphere in Kalakamate and in Botswana as a whole. However, the direction, magnitude and persistence of these changes vary from case to case. Population has increased, but at the village level the rate has not been high enough to have any pronounced effect on the environment. In contrast to national figures and to the situation in other parts of Botswana, livestock numbers in Kalakamate, as well as in surrounding areas of communal land, have hardly increased. Instead, official records and villagers' narratives both tell of a continuous fluctuation, which can be convincingly attributed to rainfall variation and events and developments generated outside the village. Turning now to climate change, and more specifically rainfall, official records and the perception of villagers are at a first glance contradictory. Official records show no clear trends, but villagers claim to have experienced a decline. We suggest that the seeming contradictions may be overcome by pointing out the differences in how rainfall is measured – by official sources in terms of mm at a rain gauge over a period of time, and by farmers in terms of how they can utilise the available moisture. The latter may well have changed because the location and character of farming activities have changed, primarily due to the nucleation of settlements. In a similar manner, grasses, trees, fruits and other natural resources are used and perceived differently owing to changes in livelihood strategies and changes in the individual's experience of these resources in daily life.

Our approach, to attempt closure and resolve contradictions in diverse narratives, leads to a remarkable convergence between local and scientific accounts and interpretations of environmental change, especially when related to recent developments in semi-arid range ecology. The following conclusions have been shown to be consistent with both sources:

a) Variations in rainfall, including events such as drought, are the main driving force of ecosystem dynamic.

b) Changes in the physical environment are event-driven, e.g. by drought, but also by other random events or planned interventions. In range ecology terms this is called an environment at dis-equilibrium.

c) Stocking densities have a relatively low importance in explaining environmental change.

d) Few, if any, of the observed changes are irreversible and of a kind that would fit any of the current definitions of land degradation.

e) A flexible strategy of land management, including a package of options to be used in an opportunistic way, is both logical and sound.

The cover and density of woody vegetation has increased, especially in parts of the village, and more specifically the spatial distribution of different vegetation types has changed. This is primarily caused by changes in the spatial pattern of settlement and cultivation, a shift initiated at the national level. Likewise, the erection of fences, which cut off access to water and grazing land, and also the reduced frequency of burning, were caused by outside intervention – single events caused long-term local changes of land use and environment. These and other examples demonstrate how people adjust to events and trends in the socio-economic sphere, and how resulting shifts in livelihood opportunities cause changes in land use, with both immediate and gradual effects on the environment at the local level.

Increased access to income opportunities outside the village has reduced the dependence on agricultural and pastoral income earning activities in general, and on certain natural resources specifically. This may have influenced the abundance and distribution of species, but it has also altered people's perception of the environment. Depending on individual circumstances, the strategies, perceptions and interpretations of change will differ from person to person and from place to place. Simply speaking, narrators, including the scientists, are perceiving aspects of the same reality in different ways, or are generalising from different experiences and/or interests. We have tried to achieve closure by explaining how these differences in perception and explanation came about, not so much by proving one account wrong and the other right, as by establishing why they differ. The inclusion of local narratives is informative in its own right, and also presents outside actors (scientists, consultants, policy-makers) with complementary and often improved means for perceiving, measuring and evaluating the environment.

Both local and scientific sources provide narratives, and both have to be 'de-narratised' when comparing them. Local narratives are not told for the same reasons as those told by scientists. Villagers are experiencing their surroundings and trying to make sense of their lives, while scientists collect data with the specific purpose of trying to reduce uncertainty and increase predictability. In the case of semi-arid areas of Africa, scientific data and their interpretation have recently been subjected to a scientific critique which emphasises uncertainty and complexity. The villagers of Kalakamate seem to have come to the same conclusion.

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NOTES

[1] Sources for figure 3 a–d:
Bechuanaland/Botswana: 1904–71 (Tumkaya 1987), 1981 (CSO 1982), 1991 (CSO 1992).
Tati/North East District: 1931 (BNA S.238/4), 1946 (BNA S.87/3), 1964 (Tumkaya 1987), 1971 (CSO 1973), 1981 (CSO 1982), 1991 (CSO 1992).
Chiefdom of Ramokate: 1921 (BNA S.17/7), 1936 (BNA S.238/7/1), 1946 (BNA S.87/3), 1971 (CSO 1973), 1981 (CSO 1982, 1983), 1991 (CSO 1992).
Kalakamate village: 1964 (BNA CENSUS 39/4), 1968 (BNA BNB 8151), 1981 (CSO 1982, 1983), 1991 (CSO 1992).
[2] Sources for figure 4 a–d:
Francistown Veterinary Region: 1904, 1911 (in Fortmann et al. 1983), 1936 (BNA S.86/15), 1939 (Fortmann et al. 1983), 1941–42, 1944–46, 1948–55 (in Fortmann et al. 1983), 1956–57 (PRO DO 112/31), 1960–61 (PRO DO 102/37), 1962–67, 1969, 1976 (in Fortmann et al. 1983), 1979–90 (Botswana 1980–91).
Tati Native Reserve: 1905 (BNA R.C.11/5), 1930 (BNA S.130/6), 1932 (in Fortmann et al. 1983), 1936 (BNA S.238/6), 1939 (BNA DCF 6/15), 1941–42 (BNA S.238/8), 1943–44 (BNA S.238/9), 1946 (BNA S.238/7/1), 1947–48 (BNA S.238/7/2), 1949–52 (in Fortmann et al. 1983),1958 (PRO DO 35/4494), 1971 (Egner 1971, App C), 1981 (RAO R12D), 1986, 1989 (Maas and Jansen 1990), 1990 (Veterinary Office 1992).
Chiefdom of Ramokate: 1930 (BNA S.130/6), 1936 (BNA S.238/6), 1939 (BNA DCF 6/15), 1941(BNA S.238/8), 1943–44 (BNA S.238/9), 1946 (BNA S.238/7/1) 1948 (BNA S.238/7/2), 1990 (Veterinary Office 1992).
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