OCCASIONAL PAPER NO. 3

SUMMER DESERTIFICATION PROJECT II (SDP 2)
A STUDY OF DESERTIFICATION AT ENGELBRECHT

January 1996

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I.O. Nghishoongele; T.M. Nghitila; E.N. Ngololo.

Desert Research Foundation of Namibia
P O Box 20232, Windhoek
Tel: + 264 61 229855
Fax: + 264 61 230172
email: drfn@drfn.org.na
website: http://www.iwwn.com.na/drfn/index.html

The Gobabeb Training and Research Centre
P O Box 953, Walvis Bay
Tel: + 264 64 202613
Fax: + 264 64 205197
email: gobabeb@iafrica.com.na

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E. N. Ngololo

Edited and Supported by:
W. J. Hamilton
P. Jobst
J. R. Kambatuku
S. Montgomery
Y. Narain
M. K. Seely
D. Ward

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Since its inception in 1994, the Summer Desertification Project has been at the forefront of raising environmental awareness and research training opportunities, especially around the issue of desertification in Namibia. Under the DRFN's auspices much work in terms of environmental research and training has been done. The authors are therefore deeply indebted to the Swedish International Authority for Cooperation and Development (SIDA), who have shown consistent faith in the Summer Desertification Project by providing basic core funding. We are particularly grateful to the Ambassador of Sweden Mrs. U. Ström and Mr. L. Karlsson for their overall commitment to environmental research and research training and environmental awareness in Namibia.

We would like to express our heartfelt gratitude to the Engelbrecht community for their co-operation in providing answers and information to our queries during the course of our field trip. Pastor E. Eiseb, Ephraim Kavendjii, Abraham _Guruseb, Johannes Skrywer and Gerson Uiseb provided us with unwavering support and knowledge and were always willing to work with us. Thanks are also due to the owner of the Huab Ranch Lodge, Mr. Jan van der Reep, who made our visit to the lodge an unforgettable experience.

Initiation of the project involved proposal writing, selection of participants and working site, networking with contributors, scheduling, logistics and selection and evaluation of literature all of which was carried out by staff of the Desert Research Foundation of Namibia, with Dr. M.K. Seely as the prime mover behind the whole project. During our stay at Gobabeb, our time was greatly enhanced by several DRFN staff who assisted by giving scientific talks, discussions and interactions with the aforementioned and speech presentation suggestions from Enviroteach staff (particularly Derick du Toit).

Special thanks go to the following individuals who contributed to the design, development and execution of the research by providing expert advice, lectures, data and encouragement: Prof. J. Booysen , Potchefstroom University for CHO, Mr. A Kooiman and Mr. D. Mouton of the Remote Sensing Centre, Dudu Murorwa of The Worldwide Fund for Nature and Prof. David Ward, Bar Sheva University.

A great deal of appreciation goes to Dr. M. K. Seely for initiating and implementing the project, the entire DRFN staff for support, and especially Prof. W. Hamilton and Kahepako Uariua-Kakujaha for their valuable information, advice and diligent review of the drafts. Thanks are especially due to the course co-ordinator Yolanda Narain, Uppsala University, Sweden, who encouraged and nurtured the project from the beginning - let us hope her faith has been justified. We would like to show our appreciation to Petra Jobst who assisted in collecting data during our field trip and for always keeping the library sufficiently equipped for our use. A special mention should also go to Jack Kambatuku who struggled patiently with draft reviews, editing work and providing computer support.

We could not fail to mention Andy Botelle and Kelly Kowalski who endured the ups and downs of the project with their heavy equipment, in their effort to get the activities on film.

Finally, we would like to acknowledge the community of Engelbrecht, fellow course participants and all who contributed time and effort to the SUMMER DESERTIFICATION PROGRAMME II but whom we may not have mentioned.

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General Summary

The 1995/6 Summer Course was the fourth of its kind to be offered by the DRFN and the second focusing on desertification as a topic, hence the title Summer Desertification Project II (SDP2). This course is different from its predecessor not only in terms of project topics tackled by the seven students from the University of Namibia, but also in the fact that all work was carried out in the same area, Engelbrecht farm, 50 km south-west of Kamanjab. Less time was therefore wasted in travelling around and moreover, various aspects, from socio-economics to biophysical ones pertaining to land degradation of a single area could be gathered. These in turn provided a broad overview or profile of all the factors at play and their environmental, economic and social influences in the area.

Like all the previous courses, where the emphasis is on training and cultivating critical thinking amongst the participants, time was not enough to gain sufficient insight into land degradation on the farm. The results that emanated from the project, summarised below, thus remain inconclusive and rather a good demonstrative baseline data than a verdict on the degradation status of the area.

Engelbrecht is a former settler farm spanning a total area of about 9200 ha. which was considered for resettlement of the Damara people, as part of a larger area, in the late sixties following recommendations by the Odendaal commission. The first people to resettle on the farm after it was bought by the Bantu Commission arrived in 1970 and comprised twelve families totalling a number of 70 people and 200 livestock. The resettlement of people was not co-ordinated by any institution, be it the Bantu Commission or the subsequent second-tier Damara Authority. Instead, Damara speaking farmers fleeing the effects of drought in other parts of the country had a free hand in moving and choosing where to resettle. It so happened that the 70 farmers who ended up in Engelbrecht in 1970 had three farms to choose from; Engelbrecht itself, Vrye and Brambach. Fourteen of the seventy people, including pastor Eiseb, stayed on at the farm at what is referred to as Engelbrecht village in this report. In about 1974, another group of people settled on the farm, 5 km north-west of the main settlement at what is referred to as Engelbrecht cattlepost.

Lying on the verge of the pro-Namib desert area, at 19° 56 ' S and 14° 40 ' E, Engelbrecht farm can be classified as an entirely arid area characterised by highly variable rainfall patterns and high evaporation rates. Daily temperatures varied between 15 (minimum) and 36 °C (maximum). The dryness of the area is illustrated by the fact that the largest amount of rainfall in memory of the present residents is the 300 mm of April 1994. The annual average rainfall range is 150 - 250 mm.

The farm is within the realm of areas indicated by UNEP as under severe threat of desertification. The soils on the farm are predominantly lithisol in a hilly rocky landscape. This landscape is dominated by mopane (*Colophopermum mopane)* forest on the plains while other tree such as *Combretum spp.*, *Terminalia spp.* and *Acacias spp.* and herbaceous plants are well represented on the farm.

The farm Engelbrecht hosts 21 (8 from the cattle post and 13 from the main settlement) households in total, with a combined population of 98 (31 from post and 67 from village) people. The stocking rates on the farm are in the area of 820 small stock (of which 300 goats belong to one person) and 330 large stock units. The people and their livestock depend on only 4 functional boreholes out of eleven drilled on the farm, mostly by the former owner. Though some boreholes were impossible to dip, the depths of those dipped varied from a 4 metre deep, shallow open pit adjacent to the main borehole on the main settlement, to an unused dry borehole 161.2 metres deep (W22053 , GPS 19° 56 ',9405 S; 14° 43 ',268 E). The two functioning boreholes at the cattle post have 8 and 12 pipes respectively. Water availability is said not to be a problem on the farm at all.

The farmers on the farm constantly have to put up with frequent elephant problems where the animals not only compete with livestock for grazing but also cause serious damage to trees and even threaten human lives. The elephants were also reported to damage water installations and fences to an extent where people have simply given up mending fences or gardening. In an effort to minimise human-elephant conflicts, a separate borehole has been provided for use by elephants about 2.5 km south of the main settlement. The Department of Water Affairs is responsible for maintance of water points on the farm.

Due to lack of fence maintenance, management of grazing and livestock movement is absent on the farm except for herding of goats as a measure against predators (jackals) and goats getting strangled in tree branches. Animals move in all directions when grazing, and cattle can go as far as the farm's borders in the dry season.

Regular recurrent droughts are a serious problem on the farm. Apart from relying on drought relief, people move their stock to other places to evade the consequences of droughts. However not everyone has the resources to move their stock around and many people are left with no option but to watch their stock perish.

Almost every tree found in the area is put to one or the other use by the community, from food and medicine to fuel wood. Mopane trees are the most used of all trees on the farm. Collection of pods from ana trees (*Faidherbia albida)* seem to be practised by a few individuals only, who mainly do it for selling rather than as an emergency fodder in dry periods. Fierce competition for these pods among livestock and elephants limits the amount people can gather. It might take a whole day to collect one bag (size of a 50 kg animal fodder bag) of pods.Fuelwood can still be found within a short distance from the village. In fact, collection of wood is amongst the three major daily activities taking up people's time on the farm, the others being cooking and tending to goats.

The economic situation at Engelbrecht is not dominated by cash due to problems selling livestock and the distant location of the farm from major urban centres (Opuuo, Khorixas and Kamanjab), and thus banking facilities. Lack of vehicular transport limits people's movements as they can't travel to Opuuo, which now hosts the regional headquarters and most of government services like subsidies, across the Veterinary Control Fence, with donkey carts. If they should cross the Redline with their carts, then the animals, the donkeys, would not be allowed to return. Thus collecting drought relief fodder has emerged as new problem for the people of Engelbrecht. Apart from the Council of Churches of Namibia's (CCN) 'food for the vulnerable', people share meat whenever one slaughters an animal.

Further details on the farm are to be found in the respective individual reports contained in this volume.

CLIMATE AND WEATHER AS POSSIBLE PROXIMATE FACTORS OF LAND DEGRADATION

Nghitila Teofilus

Introduction

Arid and semi-arid areas have received little scholarly or popular attention, yet desertification is likely to occur within such regions. In fact, these areas may well be fragile or vulnerable. Anthropogenic pressure, when combined with climatic variations, may accelerate land degradation (UNEP, 1991).

Most of Namibia's land is arid and semi-arid and has many characteristics in common with dry areas throughout the world (Seely, 1991). Rainfall in Namibia is extremely variable and unpredictable, making the country susceptible to water shortages. This variability, together with the constant pressure on the land, contributes to land degradation. The climate of arid lands can be highly variable, producing remarkable changes in the environment. Climate is one of the most important factors in an ecosystem. In Namibia, rainfall is the overriding factor affecting health and diversity of flora and fauna, which in turn, are the primary determinants of whether a specific area is degraded or not. Knowledge about the climate and weather will provide a better understanding of the Namibian environment and consequently, can suggest measures which might prevent or alleviate land degradation.

This study attempts to give the climatic picture at the Engelbrecht farm in former Damaraland (Kunene), Namibia. It also reviews some of the factors, both global and regional, which may play a significant role in producing weather conditions in southern Africa, Namibia in particular.

Southern African Weather Systems

The Inter-tropical Convergence Zone (ITCZ) brings most of the rain that falls in the southern African region (Booth, et. al, 1994). The ITCZ is the zone of intense rain-cloud development created when the Southeast Trade Winds (winds from the southern hemisphere) collide with the Northeast Monsoons (winds from the northern hemisphere). The movement of the ITCZ southward away from the Equator marks the start of the main rainy season in the Southern Hemisphere. This movement is linked to the position of the sun in relation to the position of the earth. During the summer, the sun is directly between the Equator and the Tropic of Capricorn, heating the Ocean and other water-bodies. This causes warm and moist air to rise into the atmosphere, often resulting in substantial and rain-bearing clouds.

The Atlantic and Indian High Pressure Systems are the most influential factors affecting weather conditions in the region. When these systems move southwards they cause the Westerlies to blow south over the continent.

The Indian High Pressure has its centre well out to sea. The winds that originate from this high pressure cell travel across the warm Indian Ocean picking up moisture. This air influences the eastern parts of southern Africa.

The Atlantic High Pressure System, which has its centre near the west coast of southern Africa, is a source of dry subsiding air with short sea track and carries little moisture (Hurry and van Heerden, 1981).

The air from the Indian High Pressure meets the air from the Atlantic High Pressure System resulting in the so called moisture boundary. Air from the Atlantic undercuts the Indian air, causing uplifting, condensation and cloud formation. This boundary lies south-east of Namibia and distributes some rain into the region (fig.3). When this boundary lies north of the region, drought conditions prevail, but when it lies to the south, widespread occurrence of rains is possible (Hurry and Heerden, 1981).

Upper High Pressure Systems create unfavourable conditions for heavy rainfalls and tends to push rain-bearing ITCZ and active westerly cloud-band out of the region and over the Indian Ocean (Hurry and Heerden, 1981).

Causes of drought in Southern Hemisphere

Climatologists have produced a number of plausible explanations as to why droughts occur. A single conclusive answer is yet to be found (Booth et. al, 1994). While the pattern of global aridity seems to be based on the basic global energy flux and resultant patterns of atmospheric circulation, drought occurs as a result of specific shortfalls in moisture availability in the face of specific demands for moisture. Drought can therefore occur during any unexpected shortage of available moisture sufficient to cause severe hardship to human resource use in the area affected. An expected shortage, say from the effects of the seasonal dry period, would not therefore be classified as a drought. If the shortage occurred in the normally wet season or the magnitude of the shortage was significantly greater than normal during a dry season, then a drought is said to occur.

Past drought occurrences have been linked to events such as El Nino and volcanic eruptions. El Nino is a weather condition which begins with the warming of water in the western Pacific Ocean. These natural warming events alter weather worldwide, probably causing droughts in southern Africa or contributing to their severity (UNESCO, 1980).

Droughts in southern Africa have been linked to volcanic eruptions elsewhere in the world. Climatologists believe that the eruption of Mount Pinatube in the Philippines in June 1991 could also be linked to the drought that devastated southern Africa in 1991-1992. Dust spewed by the volcano could have interfered with southern Africa's ITCZ, which brings rain to much of the region (Booth et. al, 1994).

Sources of rainfall in Namibia

The main factors which influence rainfall in Namibia are ocean currents and winds. The winds which blow from the cold water of theAtlantic Ocean as a product of the Cold Benguela Current along the Namibian coast, bring little moisture. Moreover, the cold conditions accompanying the sea breeze are responsible for an inversion layer along the coast. This prevents sufficient uplifument of the air masses and the necessary turbulence for cloud formation. On the other hand, the clouds and moisture from the Indian Ocean have to travel a long way to Namibia so that by the time they reach the country, much of the moisture is drained of. Namibia is therefore a dry country which primarily depends on the position of the ITC zones for rain.

When the ITCZ moves southwards away from the Equator, it brings plenty of moisture to countries like Zaire, Zambia and Botswana and to the northern part of Namibia. The winds that tBransfer the moisture of the ITCZ from the north of Namibia to its southern and western parts equally, travels a long distance and loses moisture in the process. This is then responsible for the steep gradient in annual rainfall from the north-east to south-west of the country. The coast only receives a maximum annual rainfall of 3mm (fig.4.). The Kunene region, and thus Engelbrecht farm, is within this low rainfall region. In addition, the orographic influences create rainfall shadow condition in the mountainous areas of Kunene.

Method and Materials

General description of the area:

The Kunene area is situated in the north-western part of Namibia. It is normally an extremely dry part of the country. According to the Koppen system of climatic classification (van der Merwe, 1983), the climate at Engelbrecht can be classified as "BWhw". This indicates a dry region with deficiency in rainfall (B), true desert (W), annual mean temperature above 18 ^{0}C (h), and rainfall during summer (w) (fig.2.).

The landscape is dominated by mountainous terrain, hills and plains. The vegetation of the region consists mainly of annual and perennial grasses, acacia species *(A.erioloba, A. mellifera* and *A. erubesces)* and *Colophospermum mopane* with sparsely distributed *Combretum* along the river course (Giess, 1955; Nghitila, 1995, pers. obs.).

The Huab and Ugab are some of the major ephemeral rivers in this region, supporting people, plant and wildlife communities of the area (Jacobson *et al*, 1995).

Specific description of study site

This study was done in early December 1995 on the communal farm Engelbrecht about 60km south-west of Kamanjab, situated 19 56 S , 14 40 E. The farm lies on the Huab river's north bank tributary, the Katemba, which flows through the main village of the farm. December corresponds to summer, which is the normal rain season in Namibia. On the first day of measuring, the area received a shower of 0.1mm. Measurements and records of daily temperatures, humidity and wind speed were made at the study site.

Measurement of soil temperature

Measuring soil temperature is necessary to obtain the value of heat flux between soil and air. The soil temperature was taken at two depths below the surface: 10 cm and 20 cm, these being the usual depths used at most meteorological stations. At this depth, the soil thermometer (of liquid mercury, range:-35 to 55 ^{0}C) was buried in the soil for two minutes so that heat could be transferred and the temperature stabilised. Then, temperature value reading was recorded on the prepared data sheet.

Measurement of air temperature

For the measurement of the air temperature, the Bailey thermocouple thermometer (Model BAT-12, -100 ^{0}C to +200 ^{0}C) was used. The instrument was placed in the shade, and readings were recorded when the figures stabilized.

Measurement of air humidity

Atmospheric humidity is uniquely related to the wet and dry bulb temperatures of a properly ventilated psychrometer (Unwin, 1980). The psychrometer consists of a pair of thermometers, one of which is covered with a wet sleeve. After pouring water on the sleeve, the psychrometer is rotated until a constant reading is obtained, both on wet and dry thermometers. These readings were converted into percentage relative humidity using the psychrometric chart 100.0 kPa (Barenbrug, 1974).

Wind speed

Wind speed was recorded by a 3-cup x 100m Windweg anemometer (Wilh. Lambrecht GmbH Gottingen). The initial numbers on the anemometer are recorded and the reading taken again after 1 minute has clapsed. The measurements were converted into m/min. The pole supporting the anemometer was about 1.8m high above the ground.

Information about rainfall, droughts and floods was obtained from the residents and the weather stations near Engelbrecht. Long term rainfall data were also obtained from these stations (Weather Bureau, Dept.of Transport, Ministry of Works, Transport and Communication, Windhoek). The four weather stations which had long precipitation, temperature and humidity records and were situated near Engelbrecht, were selected. Their rainfall records were chosen to approximate the expected rainfall at Engelbrecht, as these stations bracket the farm (map .7). An overview was prepared comparing a wet year (1974) with a dry year (1948). The latter is considered a drought year in this region. The results obtained were then arranged into three categories as:

A) Interviews
B) Direct measurements
C) Climate of the area

Results

A) Interviews

Six local people were interviewed, of which four are elderly men who have stayed on the farm Engelbrecht since the 1970s. They emphasized that the area has no reliable rainfall records. The 1995 total annual rainfall of 300mm was the best they remembered since they had dwelled at Engelbrecht, and the river had flowed three times.

Between 1980 and 1982 the area experienced a severe drought. However, the people at Engelbrecht had never had drinking water problems since they settled there, including during the 1980-1982 and 1991-1992 droughts. Because there was little or no rainfall during that period, some residents moved to other farming areas like the Usakos area, then came back there after it rained. According to the local people, the area looked barren between 1988 to 1994, but after the good rainfall in 1995 it recovered. None of them noticed any long term change in the vegetation pattern.

There is only one rain gauge in the whole of Engelbrecht but most inhabitants seldom take readings. They expressed their willingness to acquire some rain gauges.

B) Direct Measurements

Humidity and air temperature obtained by direct measurements show the same trend as the data obtained from the four weather stations (fig.5 and 6). Daily temperature is in the range of 15 to 35^{0}C, (fig.5).

C) Climate of Area

Figure 10 shows a gradient of increasing rainfall from the coast to the inland areas. Daily temperature is high with a maximum of 36 ^{0}C fig.8. Humidity is relatively low fig.6.
A comparison of rainfall of the areas located in the 19^{0} s latitude and along the longitudinal line in the range of 13-18^{0} E, indicates the increase in rainfall from west to east with variations at many places.

Discussions and Conclusion

In discussing the nature of the climate of this area, one must understand the basic characteristics of arid climates. Rainfall is patchy, unreliable and highly variable both in time and space. The north-western part of the country falls within one of the lowest rainfall regions of Namibia where high evaporation rates are experienced (fig.4.).

The analysis of the long-term data shows how variable the rainfall can be in this environment. Damaraland climate is similar to that of the Sahel: the summer rainy season is characterised by large variations of precipitation,from one year to another (Richard, 1993). Drought is a recurrent and an expected event. In 1974, good rains fell, though with variations between sites, and 1948 was a drought year. The rains of 1991-1992 failed almost completely in all Damaraland excepting the Grootberg area in the northeast. Even near Grootberg, only a few species of acacia managed to retain some green foliage along with the miraculous mopane trees (Richard, 1993). In this situation, the coefficient of variation of rainfall may be high. The mean should not be used, because it does not give a good representation of the expected amount of rainfall.

A study on drought-stressed rangelands of Eastern Australia (Caughley et al, 1987) analyzed interaction between climatic variability, plant production, plant species composition and kangaroo population. He concluded that the system became dominated by variability when the rainfall's coefficient of variation is near or exceeds 30%. This can displace the equilibrium of the ecosystem. A similar study was done in Northern Kenya by Ellis and Swift (1988), arriving at the same conclusion as Caughley (Scoons, 1994).

Unfortunately our data did not include the rainfall for each year and the coefficient of variance was not calculated. The study done on ephemeral rivers and their catchments in this area by Jacobson et. al, (1995) shows large deviation from annual mean rainfall.

Owing to high temperature and low humidity (fig.5 and 6.), potential evaporation is high, and exceeds the rainfall.

Besides the soil being rocky, low rainfall is the major factor which limits people from practising crop farming. Small-scale stock farming is the only viable agricultural practice in the area.

While a limited amount of rainfail complicated by its variable and patchy nature does not cause desertification, it limits the amount of plant biomass that can be sustained by any given area. Consequently, the productivity of the rangelands and its carrying capacity will be low, but most importantly, it will vary with rainfall and will thus be unreliable for farming. This not only hampers proper and prudent planning by farmers, but it complicates management.

Based on its low rainfall history, the farm Engelbrecht could hardly support a single farmer and his workers, now having to support a sedentary settlement of more than 16 households (see Kakukuru in this volume). Thus, the danger of exceeding the carrying capacity is real.

Therefore, better use of both past, present and future knowledge of the behaviour of the climate system in a multidisciplinary effort should be adopted to avoid possible land degradation, resulting in excessive resource use which ignores the typical and extreme climatic variations.

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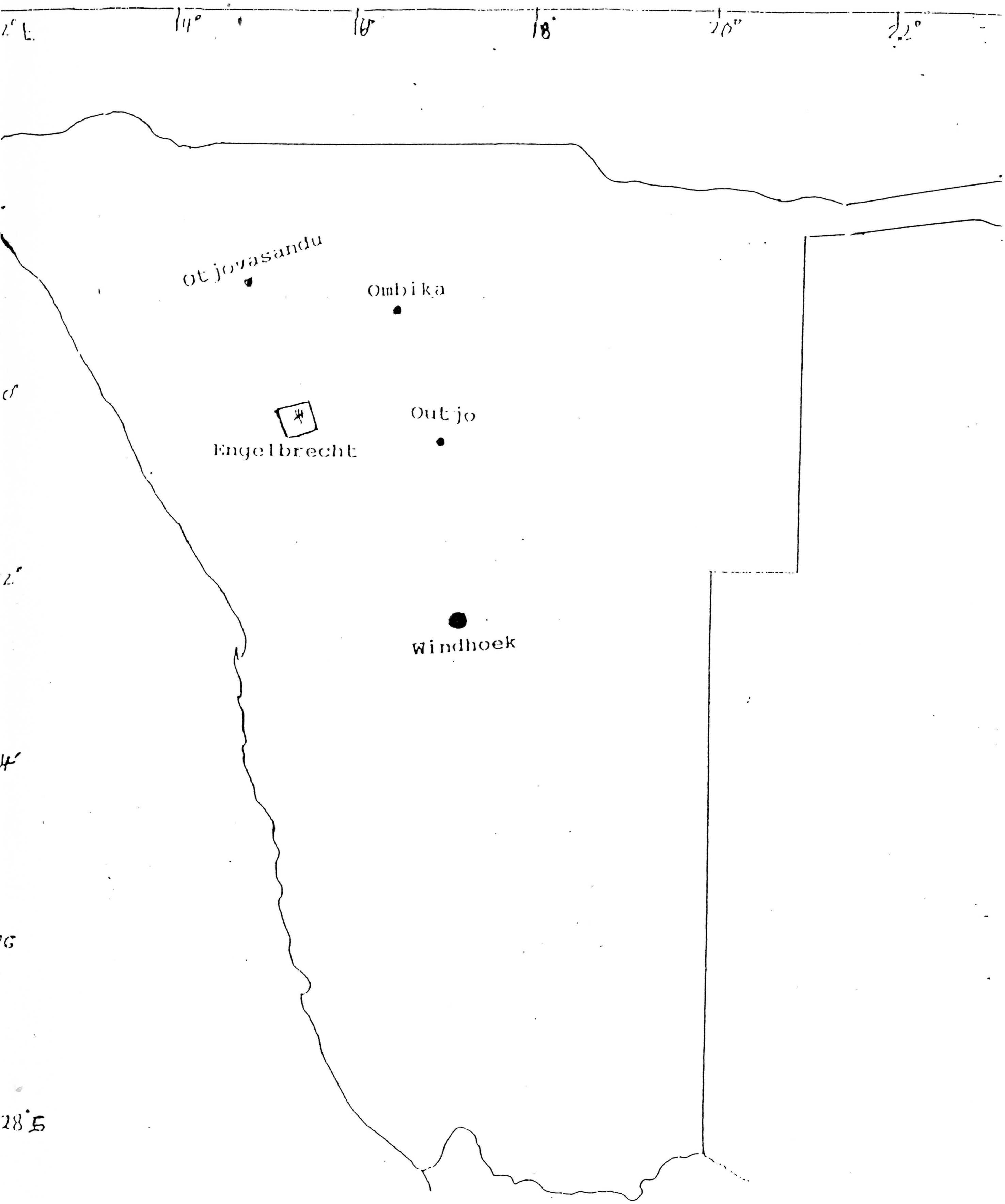
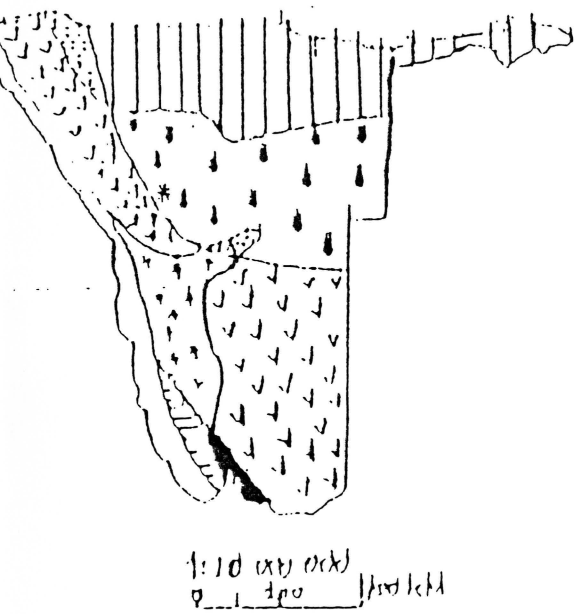


Fig.1. A map indicating the location of meteorological stations near Engelbrecht. Engelbrecht is marked with a star on the map.

Fig.2. A map of Namibia's climatic regions according to Koppen system of climate classification. The star on the map indicates the location of Engelbrecht.



egions according to Koppen system of climate classification:

he capital letters indicate the main climatic types:
B-Dry region with deficiency in rainfall
W-True desert
S-Steppe or semi-desert

he small letters relate to temperature conditions:
h-Annual mean above 18 C
k-Annual mean below 18 C
g-Month with a maximum in early summer
l-Difference between highest and lowest monthly means 10 to 22 C

he last set of small letters symbolises the rainfall and humidity characteristics:
w-Rainfall during summer
x'-Rare, intense rain showers throughout the year
n-High occurrence of fog

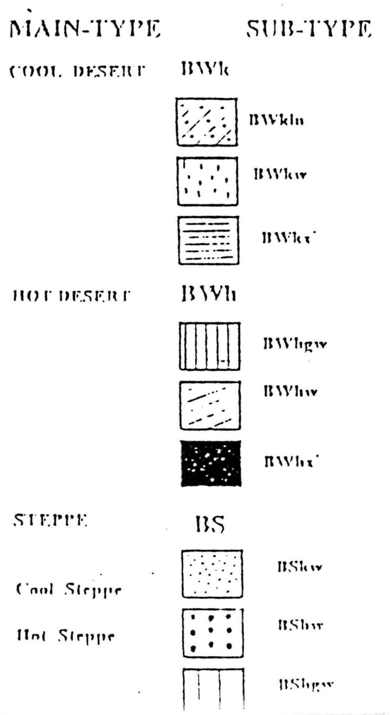
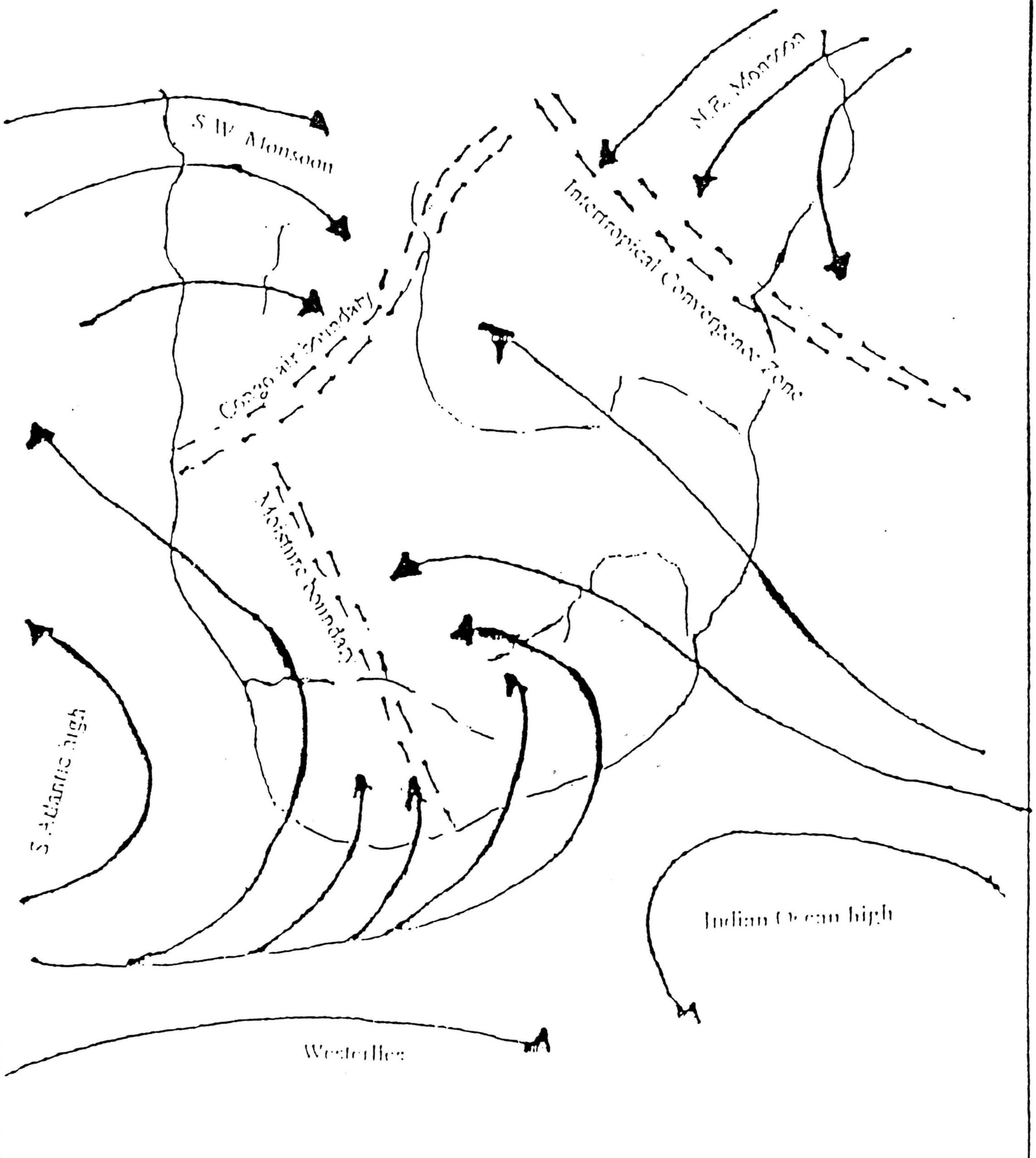
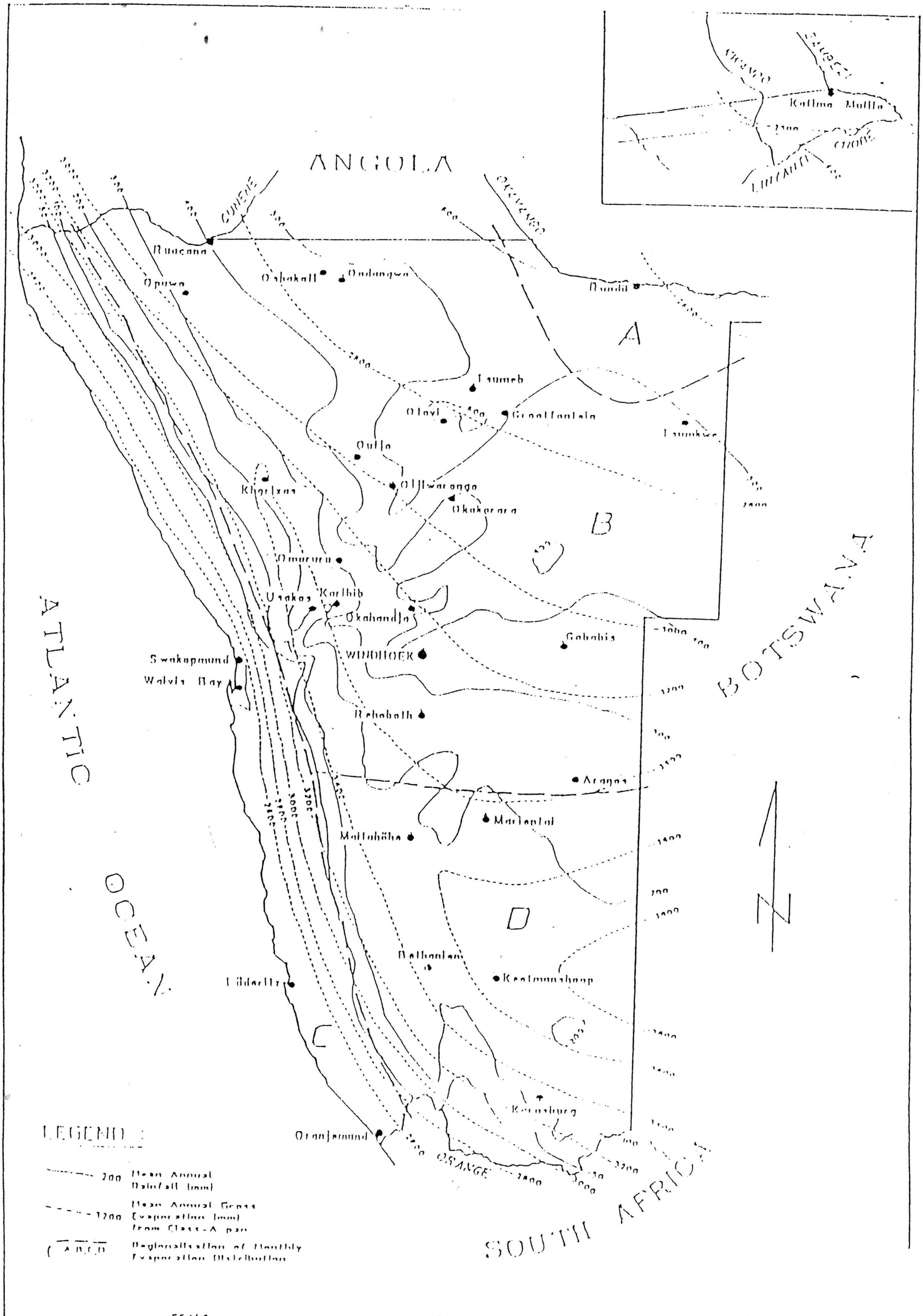


Fig.3. Basic movements of air masses over southern Africa in summer.



SOURCE: Van Heerden, J. And L. Hurry, *Southern Africa's Weather Patterns An Introductory Guide*, Acacia Books, South Africa, 1992

Fig.4. Map of annual evaporation and precipitation
The star on the map indicates the location of Engelbrecht.
SOURCE: Department of Water Affairs, Windhoek



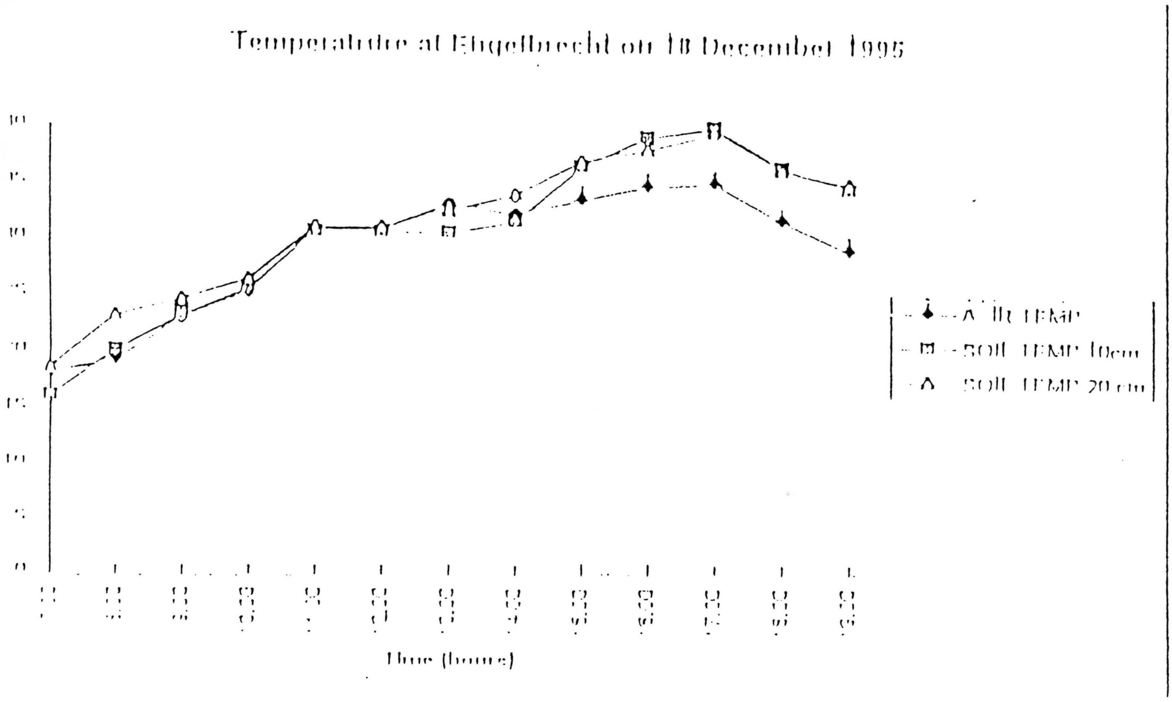


Fig.5. Air temperature and soil temperature at 10cm and 20cm recorded at Engelbrect on te 18th of December 1995.

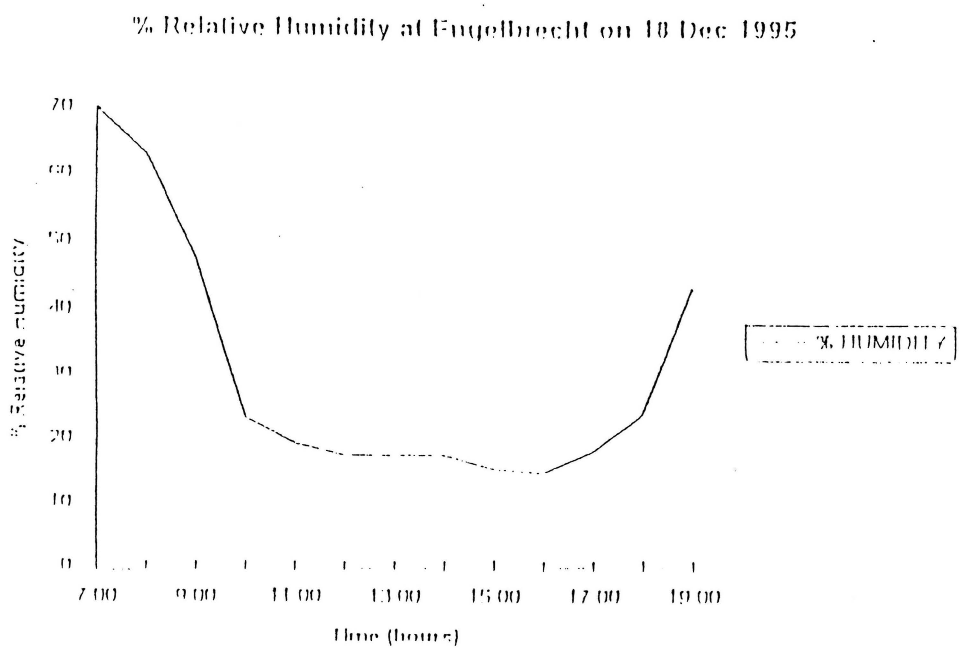


Fig.6. Daily relative humidity at Engelbrecht on the 18 December 1995. These values lie within the range of humidity measured at nearby locations. (Weather Bureau, Windhoek, Namibia).

Windspeed at Engelbrecht on the 18 December 1995

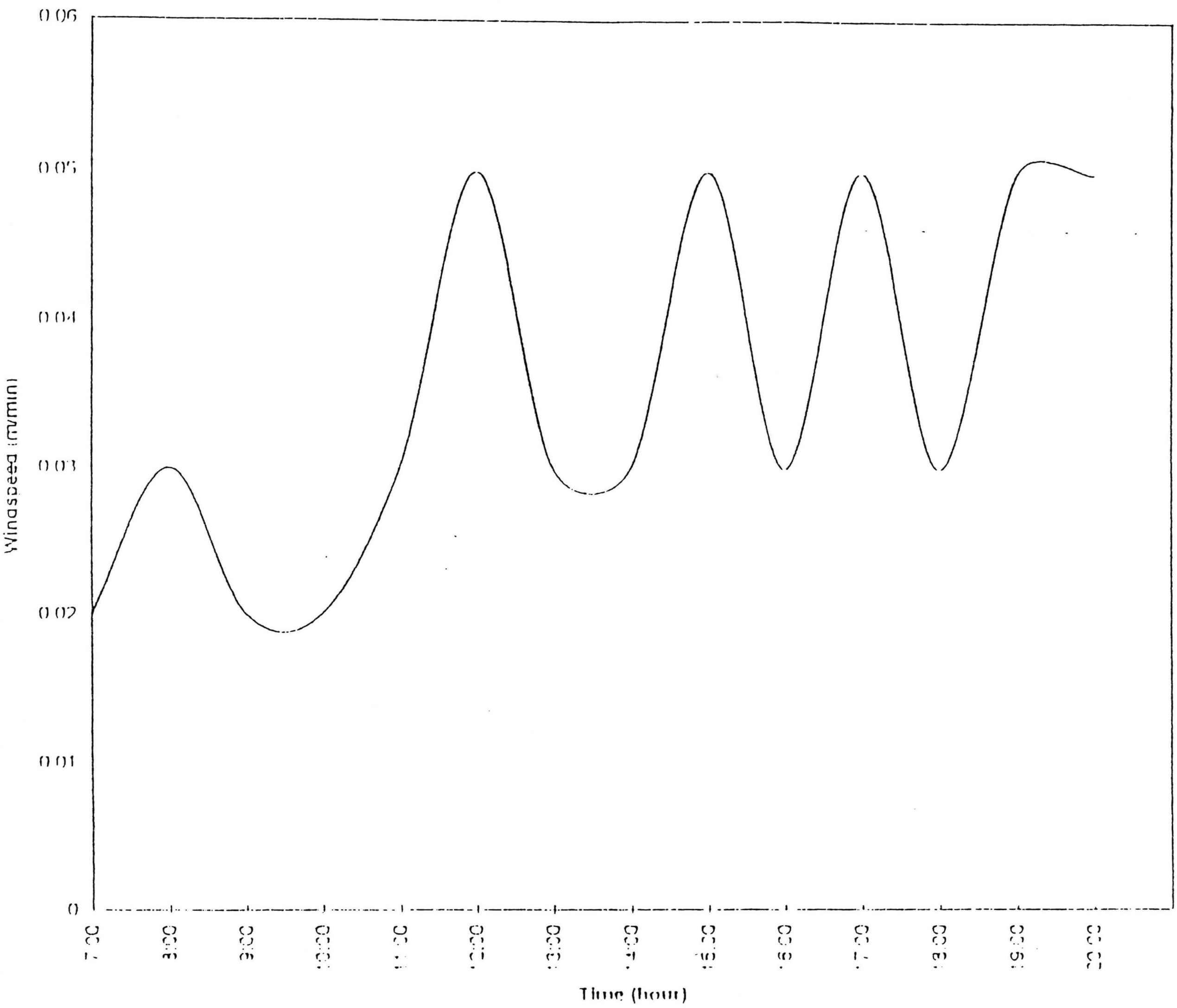


Fig.7. Wind speed changes hourly as shown in the graph.

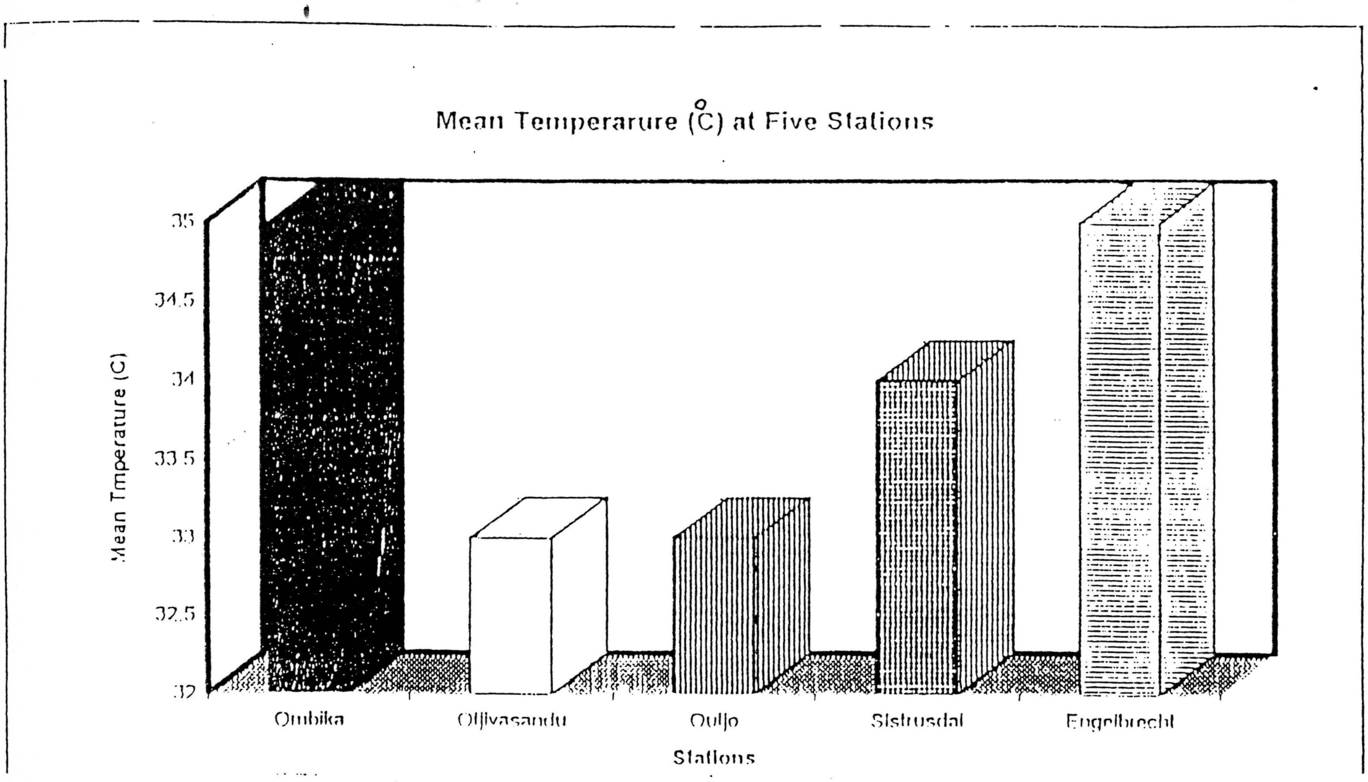


Fig.8. Comparison of mean December temperatures of five stations around the study area. Though there is no meteorological station at Engelbrecht, the data used was recorded over one week during the field work. For the other stations, averages of data recorded over 20 years, 1965-1985 are depicted.
SOURCE: Weather Bureau, Naimibia

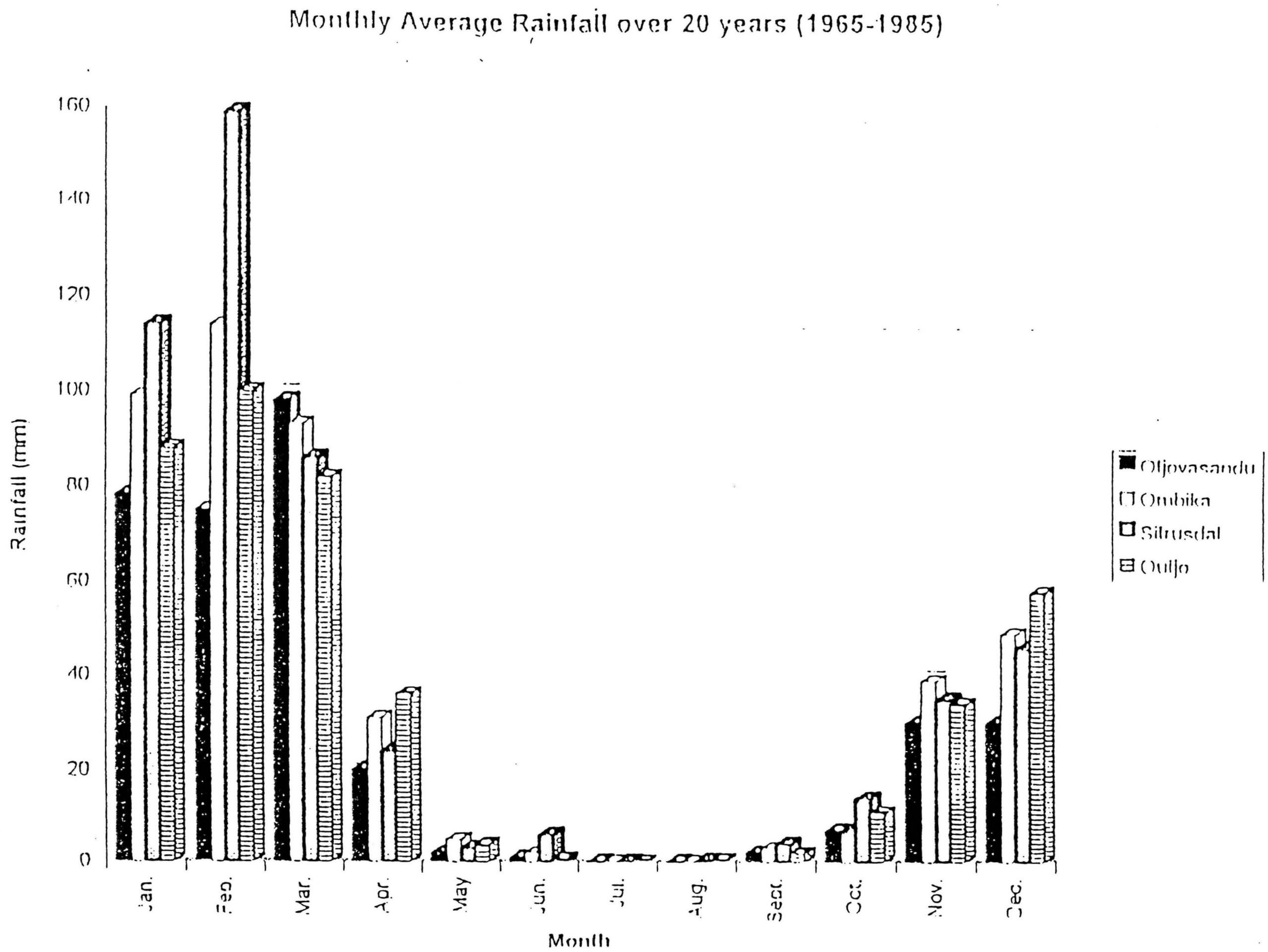


Fig.9. Monthly average rainfall during 1965-1985.
The meteorological data are obtained from stations near Engelbrecht.

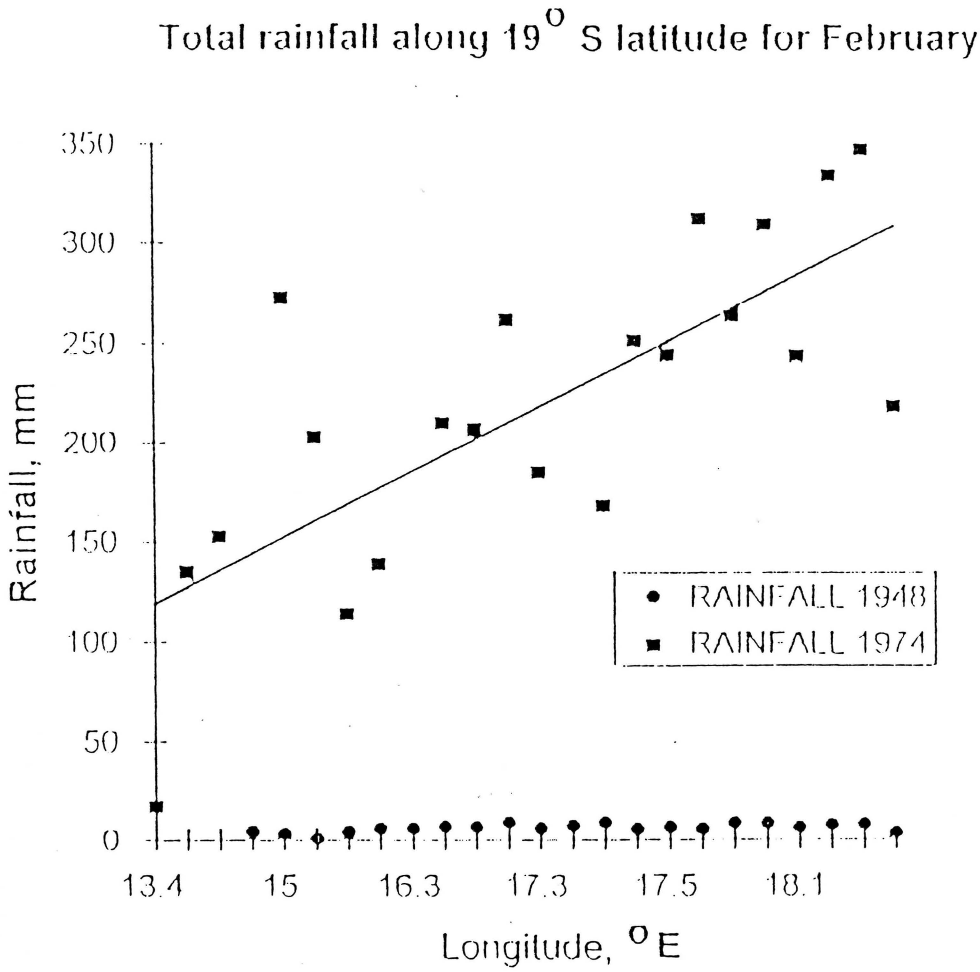
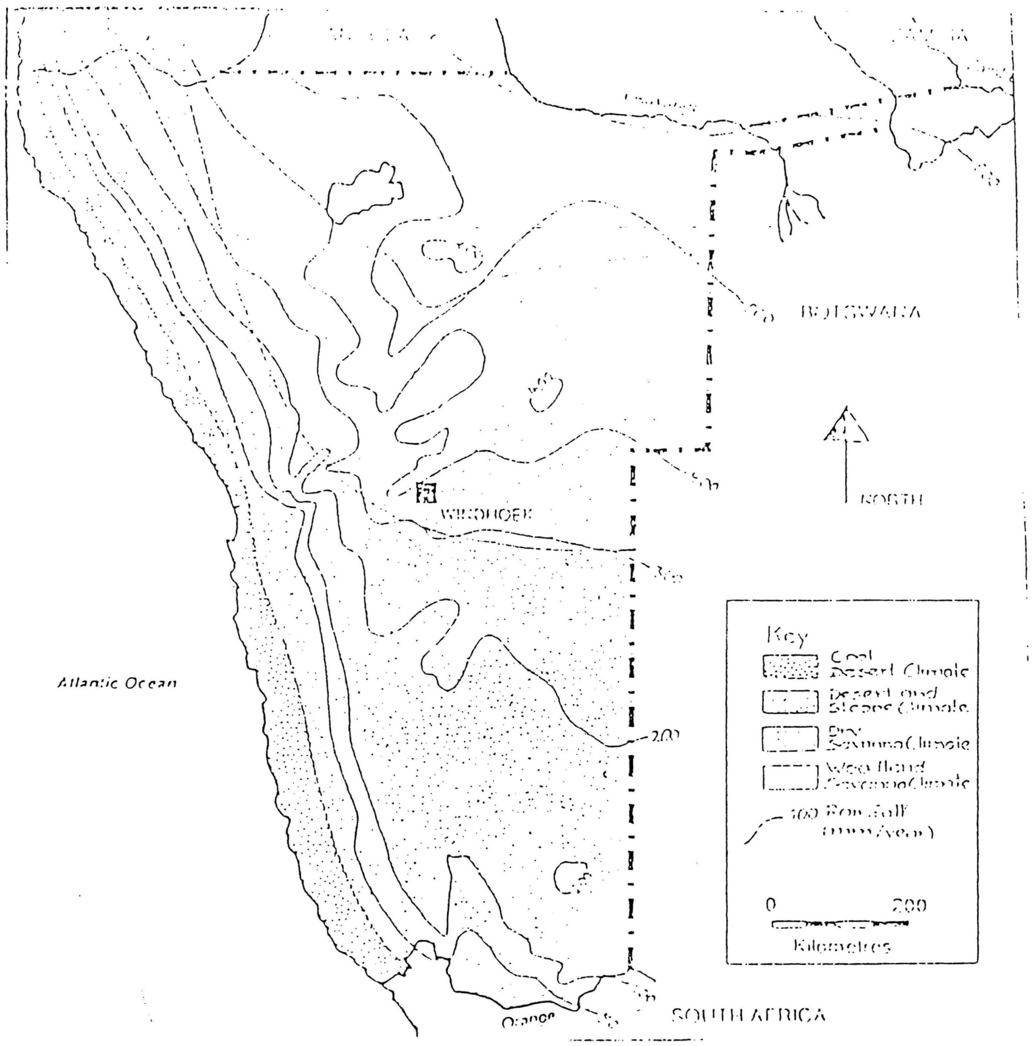


Fig.10. Total rainfall along the latitude line 19° S at different longitudes for February 1948 and 1974. 1948 was a dry year with poor rainfall as compared to the exceptionally good rain in 1974. The graph illustrates the high variability of rainfall with huge differences from year to year, a fact that makes measurements of mean rainfall unreliable. In Namibia, rainfall generally increases from West to East as shown in the graph.

Figure 11. The Climatic Regions of Namibia



MAPPING

Jacobus Guidao-oab

Introduction

The arguably unresolved question regarding the occurrence and extent of desertification in Namibia necessitates in-depth research. The most appropriate way of indicating the spatial dimension of the phenomena is through mapping. Maps are essential for the study of desertification as they may also indicate the potential for spread and the threat of desertification in geographical entities at a variety of scales such as continents, countries and regions. It is claimed that countries with a total population of 900 million people are affected by different magnitudes of desertification (Trux.A, 1993). These are countries in arid and semi-arid regions of the world with a ratio of annual average precipitation to evaporation of 0,65 (Trux.A, 1993). Namibia, thus, experiences the same potential for desertification as other arid and semi-arid areas in the rest of the world.

Namibia is the driest country south of the Sahara in Africa (Seely, 1984). To illustrate how Namibia and the rest of Africa fit into the global picture of areas under threat of desertification, it is necessary to start with large-scale maps and then to focus on Namibia and thereafter the specific study site, Engelbrecht. As Van der Merwe (1983) argues, no country exist in isolation but each forms an integral part of the larger global climatic system.

In this project, use is made of existing world, continental African and Namibian maps, as well as maps of the Engelbrecht area, to support the research undertaken in that locality.

Materials and methods

Through a literature review, a number of maps were obtained from various publications and were used as base maps for the drawing of relevant maps indicating desertification. These were maps that covered issues ranging from the extent of desertification in susceptible countries to vegetation maps, both international and local. In mapping the different phenomena, an attempt was made to always consider the relevance of the map to desertification in Namibia, with emphasis on Engelbrecht farm. To map details of Engelbrecht farm, community members of the Engelbrecht village where gathered under a tree where they draw up a sociological map, using a PRA method (see Kakukuru, this volume). The same approach was applied in drawing up the resource map for Engelbrecht farm.

Results and discussions

World map

This world map shows a large part of the world as consisting of arid and semi-arid areas and only a small portion being covered by tropical forests. Aridity refers to insufficient rainfall, less than 600 mm per year, to support vegetation in any quantity, whereas semi-aridity refers to a transitional zone between savanna grassland and true desert. Arid and semi-arid areas of the world are indicated on figure 2.1. Semi-arid areas are indicated as areas that are very susceptible to desertification in 30 to 40 years (Allan and Warren, 1993). It is noteworthy that Namibia falls into this indicated area. Thus there is no doubt that Namibia, and surely most of Africa, could face serious problems in the long run, particularly with regard to land degradation, decreased economic output and the accompanying social problems.

African map

The map of Africa gives a clearer picture of the exact extent of aridity in the southern part of the continent. The map indicates how Namibia consists almost entirely of arid and semi-arid environments (figure 2.2). However, it should be kept in mind that the extent of regions threatened with desertification is not fixed. As highlighted by Allan and Warren (1993), weather conditions vary from year to year. Periods of dry years do occur consecutively and result in local patterns of aridity which may accelerate the process of desertification. A spell of dry years does not necessarily result in desertification, but may hasten the processes that lead to it. Due to this, drought tends to be a recurrent phenomenon in semi-arid regions of Africa (Glantz, 1981). In addition, the climate of most arid environments is characterised by highly variable rainfall, low humidity, high insolation (the amount of exposure to the sun) and highly fluctuating temperatures (Seely, 1994).

Figure 2.3 indicates areas that are subject to desertification. One can clearly see how the south-western part of Africa, and Namibia in particular is at high risk of desertification. This is mainly due to arid and semi-arid zones that occur in the country.

Namibia

From the above figures, it is clear that Namibia experiences the same biophysical conditions that accompany aridity in the rest of the world. Thus the question as to whether desertification is a potential threat in Namibia can be answered from the maps and regional weather characteristics. This map largely depicts the Namibian landscape as ranging from semi-arid to arid and hyper-arid conditions. This clearly shows that desertification is a potential threat in Namibia, if it is not already a problem. For Engelbecht farm, which is located within the semi-desert transitional zone (less than 300 mm annual rainfall), the threat of land degradation may even be greater.

Engelbrecht is located in the Kunene region, in the northwestern part of Namibia and has predominantly lithosol types of soils (see figure , Namibian soil map). These soils are rendered absolutely unfit for agricultural use due to the steep, rocky, mountainous and hilly landscape (figure 2.4). On the other hand, figure 2.4 shows that there are only 1-3 persons (per square kilometre) in the Kunene region (figure 2.5). Although the area is not densely populated, the productivity of the soil is very low. Natural vegetation is dominantly mopane/savanna (figure 2.6). The vegetation is not really sufficient for livestock farming without careful management.

Social map

Despite it's potentially low carrying capacity, Engelbrecht farm has been home to a growing human and livestock population for the last half a century. The social map drawn by the community displays a current pattern of cluster-settlements, which is related to kin relationships and proximity to the waterhole. As water is fetched either on foot or with donkeys, households are situated within walking distance from the source of water. As there are neither stock camps nor automatic watering points, farmers need to personally tend to the watering of their stock on a regular basis.

Kinship plays a role in determining clustering of households as single households expand with growing numbers of family members. The social map seems to indicate that the road also plays a role in determining the position of individual households.

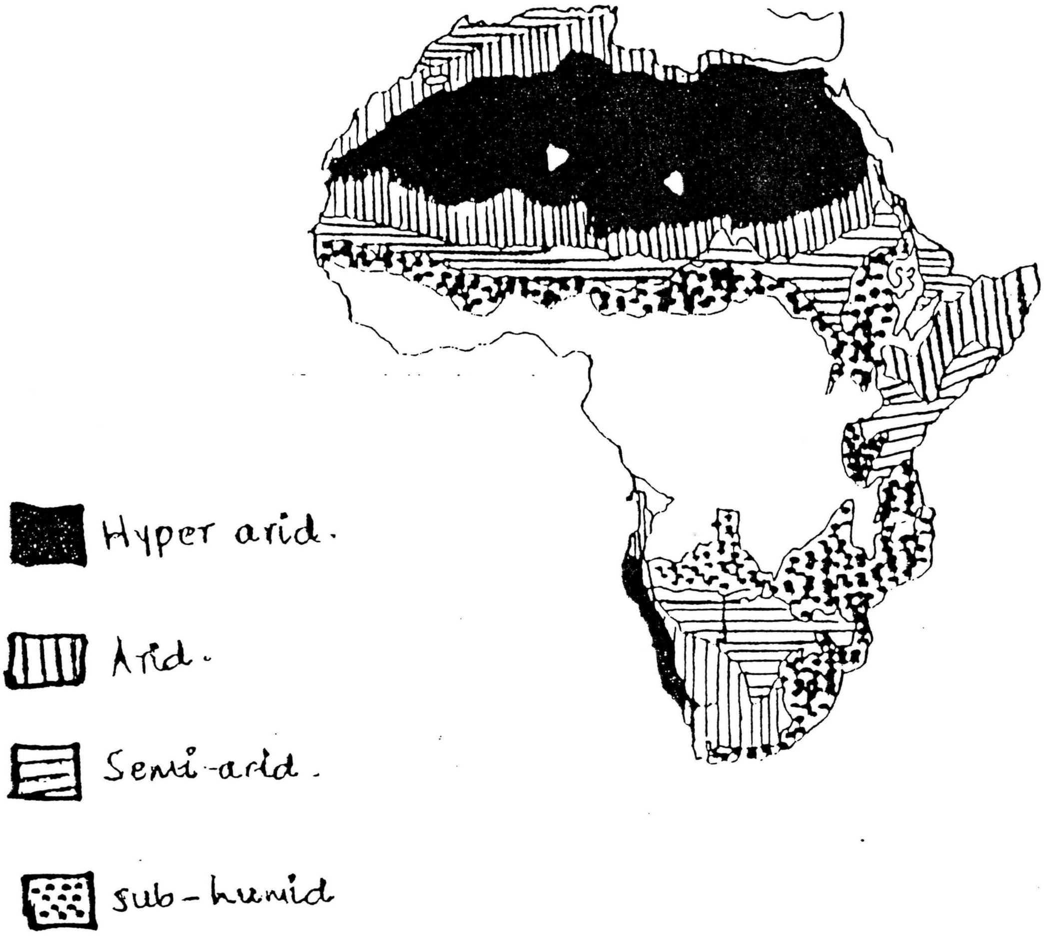
Resource map

The resource map of Engelbrecht village depicts things such as cultivated land, water, grazing areas, roads, rivers and farm land. This map was also plotted with the input of the local people, figure (2.11). Through interviews with the community, use and management of both cultural and natural resources on the farm were established. Personal views of the local community on their environment, problems and carrying capacity of the farm were also gathered in the process. Elephant activities emerged to be the most outstanding problem that the community at Engelbrecht continuously has to deal with.

The farm has 11 boreholes. Four boreholes are operating: one for local human water supply and one for elephants at the main village and the other two for cattle post. Not only do the community's livestock have to compete with elephants for pastures, but also water installations, gardens and trees suffer regularly from elephant damage. The community has, in fact, given up on cultivating and established a separate watering point for elephants with the help of WWF a mile further away. Further research will establish why the rest of the boreholes do not work. Some of these still have water.

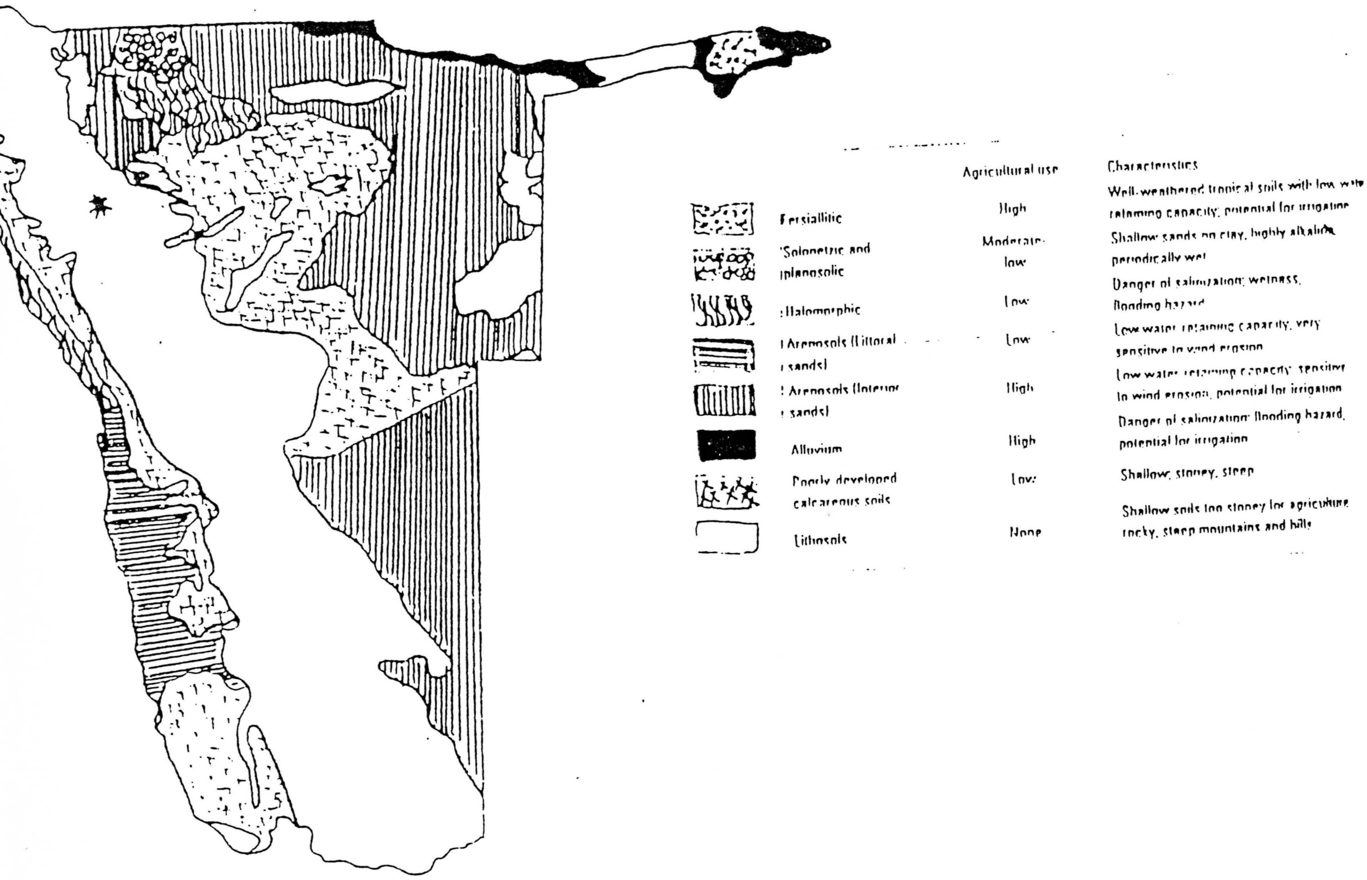
We also looked at livestock diversity and grazing areas. The Engelbrecht grazing map indicates how the area is utilized by livestock according to their preference (figure 2.10). It is noteworthy that all animals grazed equally on the area. The stock graze on the plains during rainy season then they move to hilly plains once area 1 is overgrazed. After areas 1 and 2 have been overgrazed, they normally move to area 3, which is rocky and mountainous.

Figure 1. African map showing classifications of areas according to aridity.



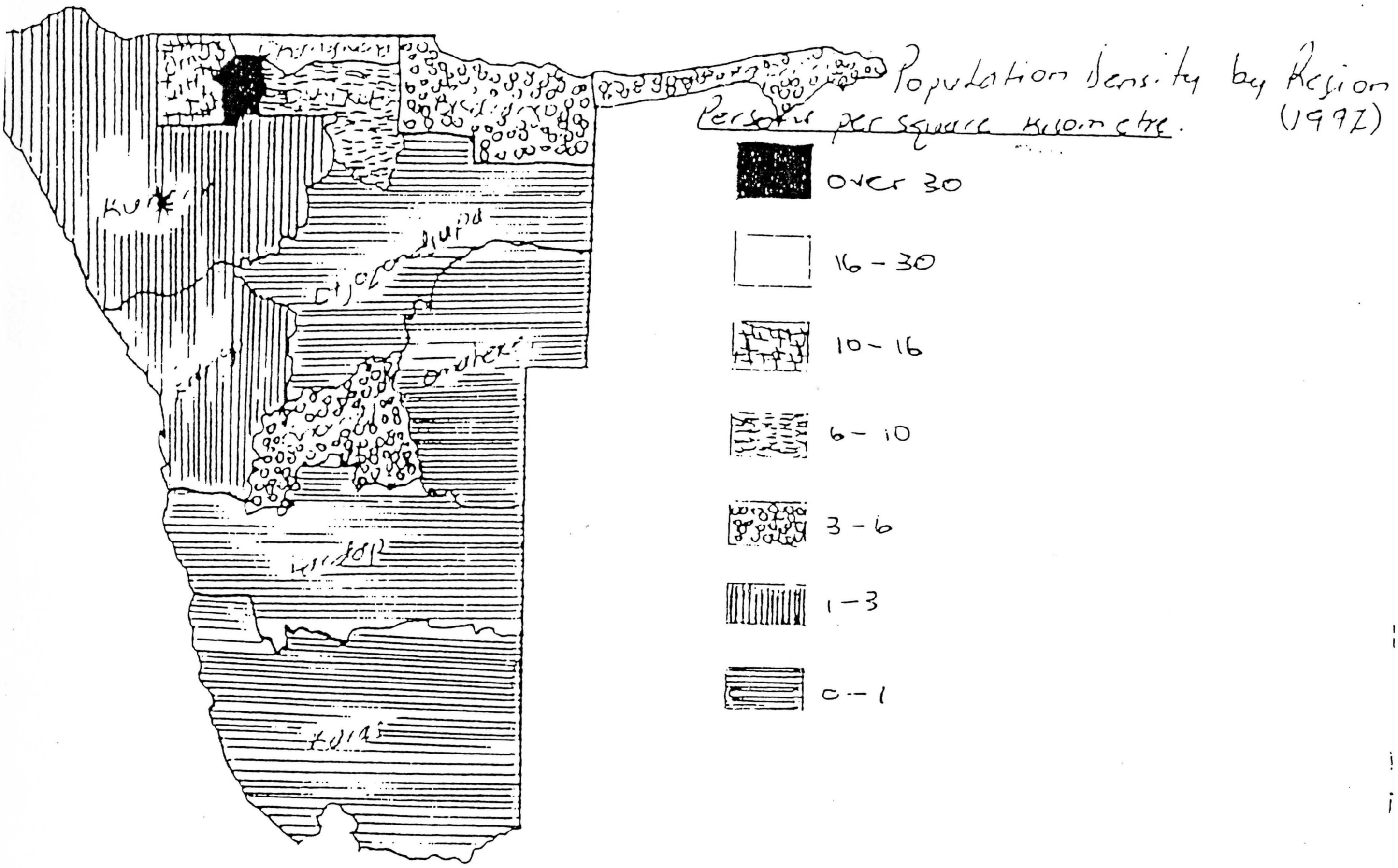
This map clearly shows that Namibia comprises most of the hyper arid and arid area in southern Africa.

Figure 2. The position of Engelbrecht on the Namibian soil map



Engelbrecht falls within the lithosol region and hence has not agriculturally usefull soils

Figure 3. Namibia population distribution by region in 1991.



POPULATION DEMOGRAPHICS AND OTHER SOCIAL ASPECTS OF ENGELBRECHT

Elizabeth Kakukuru

Introduction

The debate on environmental change in the dry lands of Africa, especially in the context of land degradation, is filled with confusion and disagreement concerning the magnitute, severity and causes of observed changes (Warren, 1988; Agnew, 1988). Bouriere (1983) reported that in reviewing the recent literature on land degradation, especially in Southern Africa, there is a need to understand the causes behind existing contradictions. On the other hand, there is a common belief that inappropriate farming methods and overgrazing are turning large areas of Africa into deserts (Bouriere, 1983). However, many other factors including the uncontrollable climatic variations contribute to land degradation. Increasing pressure on natural resources is causing a decline in the productive capacity of many areas. The question still remains to what extent statements on land degradation issues are based on an understanding of an ecology characterised by change, variability and heterogeneity. Alternatively, to what extent are such statements based on ever-changing perceptions of nature and the relationships between man and the environment (Jeffers, 1994).

The causes of land degradation are defined at both national and international level. Meyers (1992), agreeing that other factors contribute to the total efect of land degradation, claims that population growth is the agent behind natural resource depletion. Contrary to this, Stern (1993) reports that there is no convincing evidence that a stable human population would treat the environment better.

Standford (1976) identified four main groups of arguments concerning the cause of dry land degradation, which include social and economic structures, largely uncontrollable climatic events, the short-sightedness of governments, donors and animal population growth.

Namibia is a dry country with low and variable rainfall. The country is sparsely populated but has a high annual population growth rate of about 3%. The population is unevenly distributed as a result of the division of the country into homelands, delimitated by the Odendaal Commission according to ethnic criteria, and the uneven distribution of natural resources. Lau (1993) reports that those who were to make a living from the land were no longer in a position to make any decisions regarding short-term and long-term developments, investments, purchases and land tenure. Nor were they in control of the financial or other means which were required for even small scale projects.

The information for this study was collected at a farm called Engelbrecht which is about 50 km south-west of Kamanjab, from the 12th till the 19th of December 1995. It is part of an overall study that is looking at the evidence of land degradation in the western part of Namibia. This specific section focuses on population demographics.

The total population determined by the 1991 national census for the Kunene region comprises 4.2 percent of the total population of Namibia. The Khorixas constituency comprised 21 percent of the total population of the Kunene region. The total population of the farm Engelbrecht in 1987 was 48 people.

Materials and Methods

The methodology used in this study is called PRA (Participatory Rural Appraisal), a method first initiated in the 1970s to replace or improve on RRA (Rapid Rural Appraisal). RRA method extracts information in a short period of time and the results may or may not be shared with the community. With PRA, the information is extracted for a long period of time and is shared with the community while researchers are still in the field (Okali et al. 1994). It is usually carried out in the field by an interdisciplinary team working closely with the local people. This method is designed to generate information on local conditions and the people's livelihood. It also helps to stimulate, sustain and strengthen the participation of the local people in research activities (Keregero,1992). PRA tools are most widely used in participatory research involving farming (Okali et.al, 1994).

To initiate the PRA investigations, community members, ranging from elderly people to younger ones, were gathered under a tree and were informed of the activities that were going to take place. The following PRA tools were used in the study.

1. Social mapping:

The first tool used was social mapping of the area. Community members, eighteen women and six men, participated by drawing the location and relative positions of households on the farm. The researchers also participated spontaneously. Information on the number of households, household ownership, age composition, gender, emigration and immigration was indicated on the map. The local people drew and coloured maps and models of the area with locally available materials, following minimal instructions from the researchers and guided mainly by questions.

The local materials used in drawing and colouring, included sticks, stones, ash, goat droppings, leaves and grasses. Models and maps were then transferred onto paper by the researchers (map).

2. Transect walk:

A group of four researchers took a walking tour of the village with the guidance of one villager. This villager is employed as a game guide by the Huab River Project, which is funded by WWF (World Wildlife Fund). He is responsible for counting the individual elephants as well as the number of groups in which they are moving about. Information was obtained through observation and discussion with the villager mainly by asking questions. Researchers also acquired information on the location of the boreholes, when those boreholes were drilled and where the grazing area and fences were.

3. Venn diagram

The villagers were requested to map the relationships between the community, traditional leaders, government and non-governmental institutions operating in the area. First, one member of the PRA team drew a large rectangle which represented the village. Then, the villagers were asked to indicate which of the various institutions available to the village related to their day-to-day lives. It was further explained to them that the institutions that related more to the community's life were to be drawn close to the rectangle representing the village and those that did not could be indicated further away from the village. The bigger the circle, the more important the community perceived that institution and vice-versa. Then, a villager was asked to indicate how the selected institutions were related to their daily lives. The various aspects mentioned according to institutions were water, grazing capacity, livestock numbers, permission to sell stock, livestock vaccination, drought relief, food aid and auctions. Each of these points was given a sign which was placed inside a circle of the institution were it belonged to (Fig.1).

4. Interviews:

Some of the information was gathered through semi-structured interviews with the villagers, especially with the oldest residents of the area. These are the people who have lived in the area for a long time and know the area well. Interviews were also conducted with some people who were not present during the PRA activities to confirm the information gathered.

Results:

The results are presented in two separate sections, one for the village Engelbrecht itself, the other section covering the settlement known as the Engelbrecht cattlepost situated approximately 5 km from the main village settlement.

Engelbrecht cattlepost:

The current occupants of Engelbrecht cattlepost have been living on the farm for 19 years, but they moved temporarily to a farm near Usakos during the drought of 1980 and also from June 1994 until July 1995. There are 8 households at this post with a population of 31 people of which 35.5% are children. There are only 4 schoolgoing children who account for 36.4% of the population at the post. Water availability is barely considered a problem at Engelbrecht post. The grazing area is still perceived by the community to be good and sufficient for their livestock.

There are two boreholes, one fitted with a diesel pump with 12 pipes and the other one is a windpump with 8 pipes. The wind pump is used for emergency water when the diesel-powered borehole is broken. There are approximately 400 goats and 48 cattle at the post.

Fig. 3a shows that there has been an increase in both the number of small and large stock at the post during the period of 8 years even though there was a decrease in both during 1991. Only 4 people receive old age pensions while the rest rely on their livestock for a living, by selling them during auctions at a place called Driehoek, a nearby farm. They are also supplied with food by the CCN (Council of Churches in Namibia) on an approximate three months basis. This food was initially meant for pregnant women and small children but is now used by all.

Engelbrecht village:

Population composition:

The population composition of the Engelbrecht village is presented in table 1. There are 13 households at the village with 67 residents. The male composition of the population is 24%, and 4 of the sixteen adult males live in towns and visit the farm only during holidays.

Table. 1. Population Composition of Engelbrecht Village

No. of Households	Male	Female	Number of School-going	Children Non-schooling
1	1	1	1	0
2	1	1	1	1
3	1	1	1	0
4	1	1	0	0
5	1	1	0	0
6	1	1	3	3
7	1	1	2	1
8	2	1	1	2
9	1	1	0	3
10	1	1	1	3
11	2	3	2	3
12	2	2	0	1
13	1	2	0	5
Total	16	17	12	22

Females comprise 25% and 51% are children. Only 35% of the children are school-going and the remaining 67% are either small babies or children who help their parents with farming, although they are of school-going age. There is only one woman-headed household at the farm.

Fig.3a. shows that there is a trend of increasing numbers of large stock units at the village, whereas, on the contrary, the small stock decreased from 700 in 1987 to 420 in 1995. At the post, both small and large stock follows the same trend, decreasing in 1991 but increasing in 1995. Fig.3b. shows that even with the decrease in the numbers of small stock at the village, the increase in small stock at the post balances the total number of small stock at the farm. Thus, the total number of small stock at the farm decreased in 1991, from 810 in 1987 to 718 but increased again to 820 in 1995. The overall number of large stock at the farm has increased significantly over the period of 8 years, from 146 to 330 (Fig.3b.).

Emigration and immigration:

The first residents came to settle in the area in 1970 from Ovitoto after the farms were bought by the then Bantu Commission for resettlement of Damara people. A group of seventy people with approximately two hundred cattle originally came to settle on the farm where they had to choose between three farms namely Engelbrecht, Vrye and Brambach. Only fourteen of the seventy people decided to stay at the farm Engelbrecht. Only two of those pioneer residents and their families are still on the farm as the rest have died and only their grandchildren still live there. Immigration and emigration into the area is not extensive but the village is growing through expansion of the families.

Kinships:

The households are clustered in groups according to the relationships of the people through marriages and relatives. Kin-relationships also contribute to the migration of people from other areas but this was reported to be happening at a minimal rate.

Relationship of community to various institutions:

The church is closer to the community than any other available institutions possibly because it is located on the farm (fig.1). The sign of water within the circle representing the church indicates that the pastor, who lives on the farm, is the person who reports any of the problems concerning water to the Department of Water Affairs and also takes care of the waterpoints. When he is away, there is always somebody who represents him.
The results also show that the chief, council and the headman have no contact with the community even though they are the ones involved in the drought relief issues. The community has some direct contact with the agricultural and veterinary extension officers as well as Rural Water Supply, which falls under the Department of Water Affairs and deals with their water problems. These officials visit the community relatively frequetly and organize auctions, vaccinations, count their livestock and give them advice on the grazing capacity of the area.

Social Welfare:

Only 10% of the population of Engelbrecht are old age pensioners. The rest of the people depend on their livestock and food provided by the Council of Churches in Namibia. Livestock is sold during auctions twice a year and the number of animals sold depends on the owners themselves. Those who do not own any livestock live on the mercy of the others; it was reported that when the pastor slaughters an ox, the meat is shared among the villagers.

The community raised the concern that their desire for making gardens is made impossible by the elephants as they fear that the elephants could destroy them. The elephants were noticed to have increased in number since the people settled on the farm in 1970 when they did not see elephants or have problems with them. The only animals they had problems with then were lions and leopards (Eiseb, pers.comm.).

Discussion

Engelbrecht farm covers an area of approximately 9200 ha. The population at Engelbrecht has grown from 48 people in 1987 to 98 people in 1995, showing that the population of the farm has doubled in the past 8 years (fig.2). The population at the farm is growing at an alarming rate of 13%. The result will be too many people and too many livestock in a confined area which may lead to land degradation and ultimately to desertification. Jeffers (1994) reports that livestock overpopulation and high density of human numbers leads to deforestation and overgrazing which ultimately results in the destruction of the livelihood of the people themselves.

The decrease in the number of small stock at the village (Fig.3.a), is probably due to the drought of 1992. Rohde (1993), reports that most of the Odendaal farms were seriously affected by the drought of 1992. Cattle, being the most vulnerable, were the first to be moved to alternative grazing. Although most farmers wanted to move, they had nowhere to go. The total small stock deaths due to drought were 35%. De-stocking of cattle through auctions throughout 1992 showed an increase of sales by about 40% over the previous year, and taken as a whole, represented a reduction in the total herd of less than 20% (NISER, 1992).

The improvement in human and veterinary services and the availability of modern medicines has helped increase human population and livestock numbers. Traditionally, livestock are kept for many reasons, as a source of food, a symbol of status but it also plays a major role in many social functions including marriages. A large number of cattle are also kept as insurance against loss due to drought or disease. Hence, it is difficult to convince a farmer to reduce his herd size.

Botelle and Rohde (1995) report that in many rural areas of Namibia, a government pension of N$135 per month is the staple source of income, especially in the areas where agriculture is extremely marginal and this small amount can make a difference between absolute poverty and a reasonable food security. Only 10% of the population of the farm Engelbrecht are old age pensioners. Very few households have large enough herds to sell livestock. As a result, the income derived from livestock plays a minor role in the economy of most households at Engelbrecht but this also applies to other parts of Namibia. Some households have less than 10 cattle and even if they had to sell some, this would just be 1 or 2 per auction which take place twice per year.

All water for human, livestock and game (eg.elephants) consumption is obtained from the boreholes and there is a reservoir at each borehole. There are altogether eleven boreholes at this farm with only four still operating. The others have dried up possibly because of a drop in the water table (Hanan, 1991). The area is known to have a low and variable rainfall. The expected amount of rainfall ranges between 59 - 339 mm per annum (Dealie et.al, 1992). Thus, the water extraction could be far greater than the ground water recharge. This might be due to the lack of long-term planning in the region between Rural Water Supply and the NGO'S operating in the area. Given the fact that Namibia's population is growing at a very high rate, this correlates with the increase in the utilization of natural resources such as water and trees.The question is how long Namibia will still be in a position to support its population with water, as one of the scarcest resources, if already today some of the areas can barely support populations in their marginal life styles.

The drilling of boreholes as an act of drought relief does not solve the problem but adds to the already existing ones. This results in a large number of boreholes in a certain area which are in some cases drilled next to the other one, causing the depletion of grazing in the areas between them (see Ngairorue in this volume). The cost of barren areas immediately surrounding each borehole is far outweighed by the beneifts of more efficient fodder use and higher livestock populations (Hanan, 1991). Very high densities of boreholes in arid environments may result in a decreased resilience of the system as the diverse nature of the environment is destroyed. All these can lead to land degradation.

Other areas in the western part of Namibia where elephant problems are reported, often include villages such as Onverwag and areas surrounding the Palmwag lodge. Elephants are reported to cause damage to gardens as well as breaking down the waterpoints (Jobst et al, 1994). In other parts of the country, especially the Eastern Otjozondjupa region, the major constraints to increased irrigation and gardening is the lack or absence of water (Botelle and Rohde, 1995).

More than 90% of the population use donkey-carts as their major means of transport. The community needs support services from the government, especially medical care, as they reported that it takes them a whole day to ride by donkey-cart to the nearest clinic which is in Kamanjab. The mobile clinics, which are part of a wider health programme including the rural health promotion and community health education of the Ministry of Health and Social Services, do not extend their services to some of these areas.

One interviewee stressed the point that he does not think that there is still enough place for other people to come and settle at the farm, as he feels that too many people on a farm will enhance theft. Namibia's high population growth rate correlates with the increase in the utilization of natural resources, such as trees and water. But for how long will Namibia still be in a position to support its population if people are even now settled in areas which are barely able to support a marginal lifestyle?

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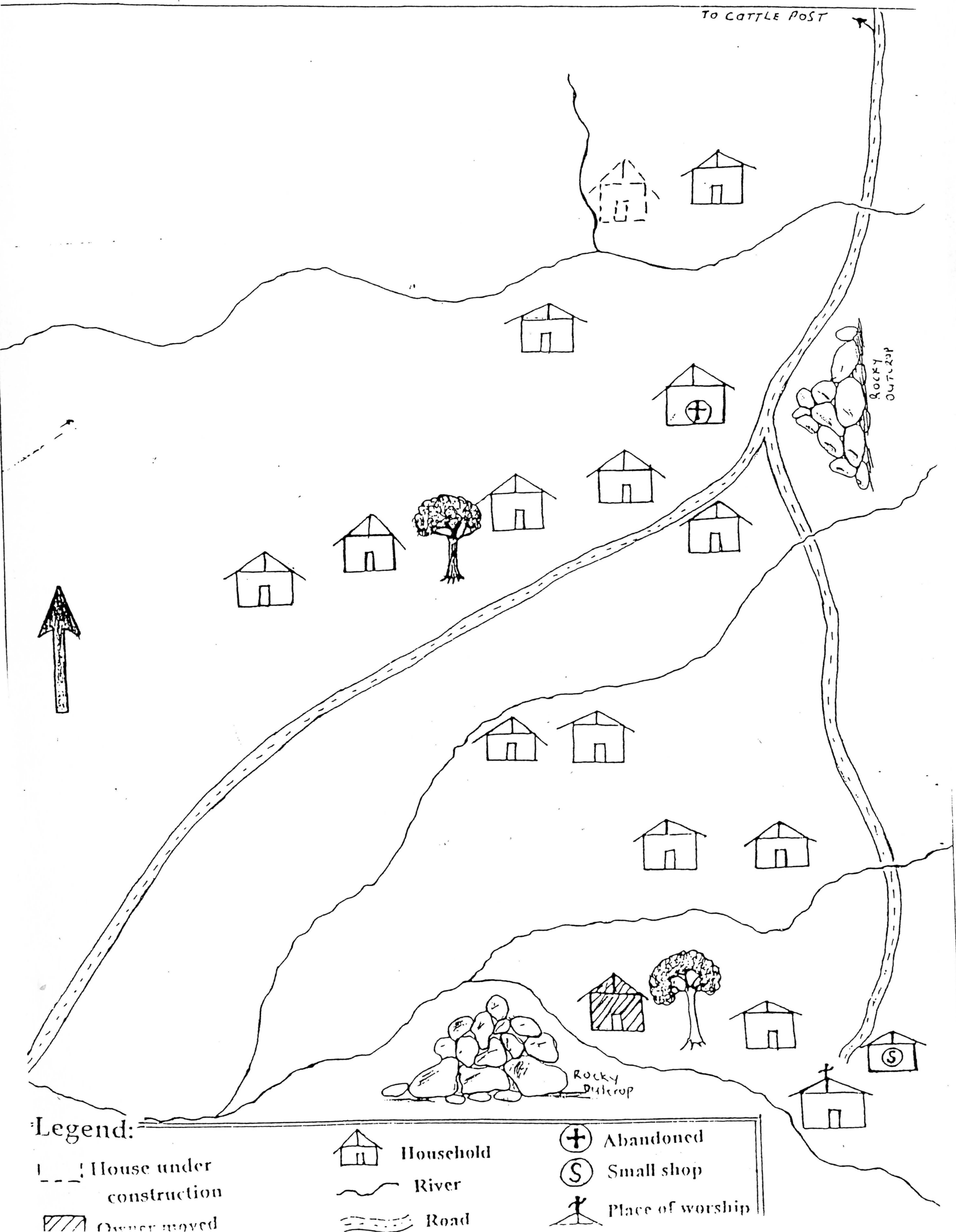
FARM ENGELBRECHT 272

- SOCIAL MAP 1995 -



1 Schematic diagram showing the relationships of the Engelbrecht community to the various institutions.

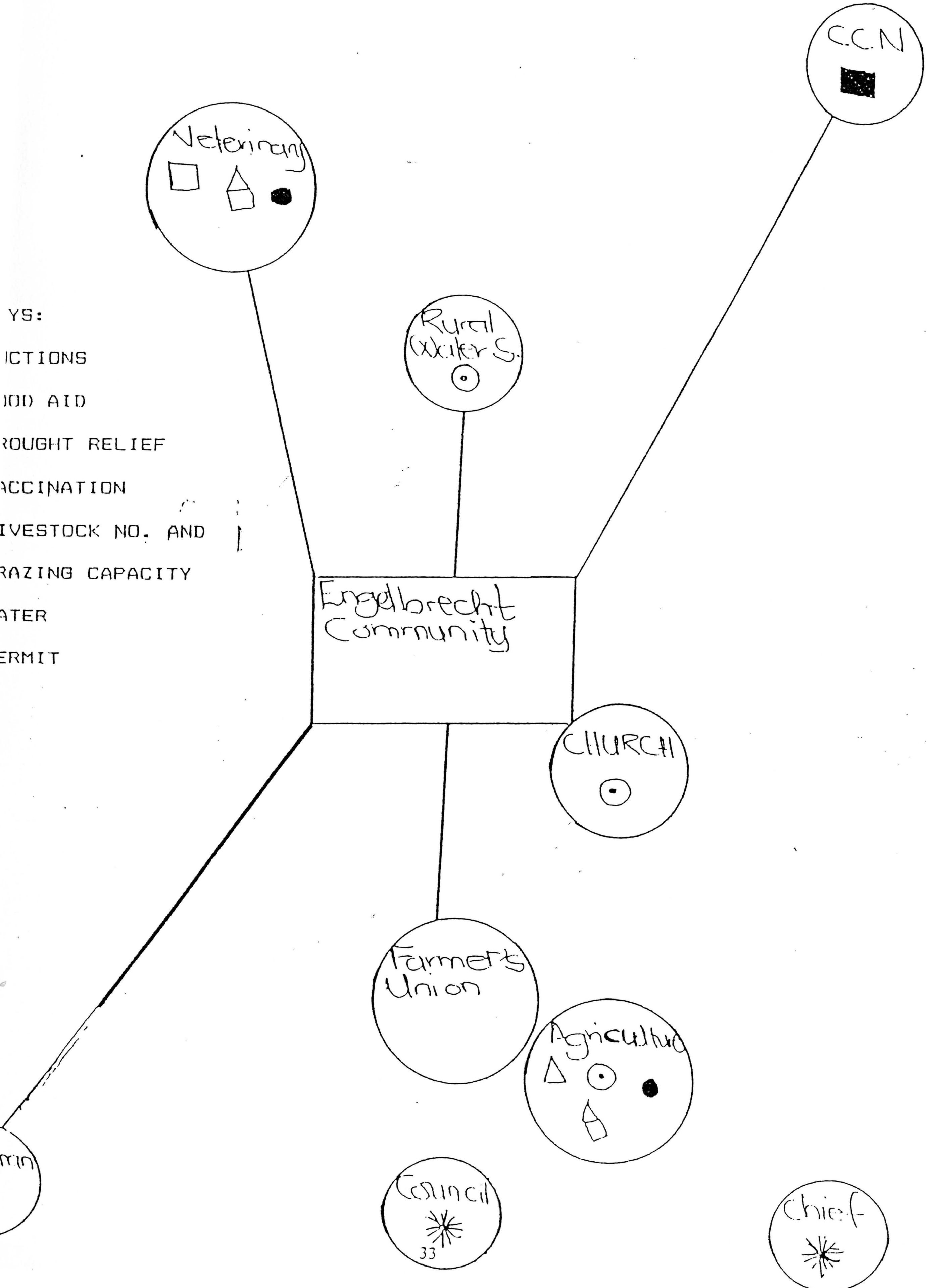
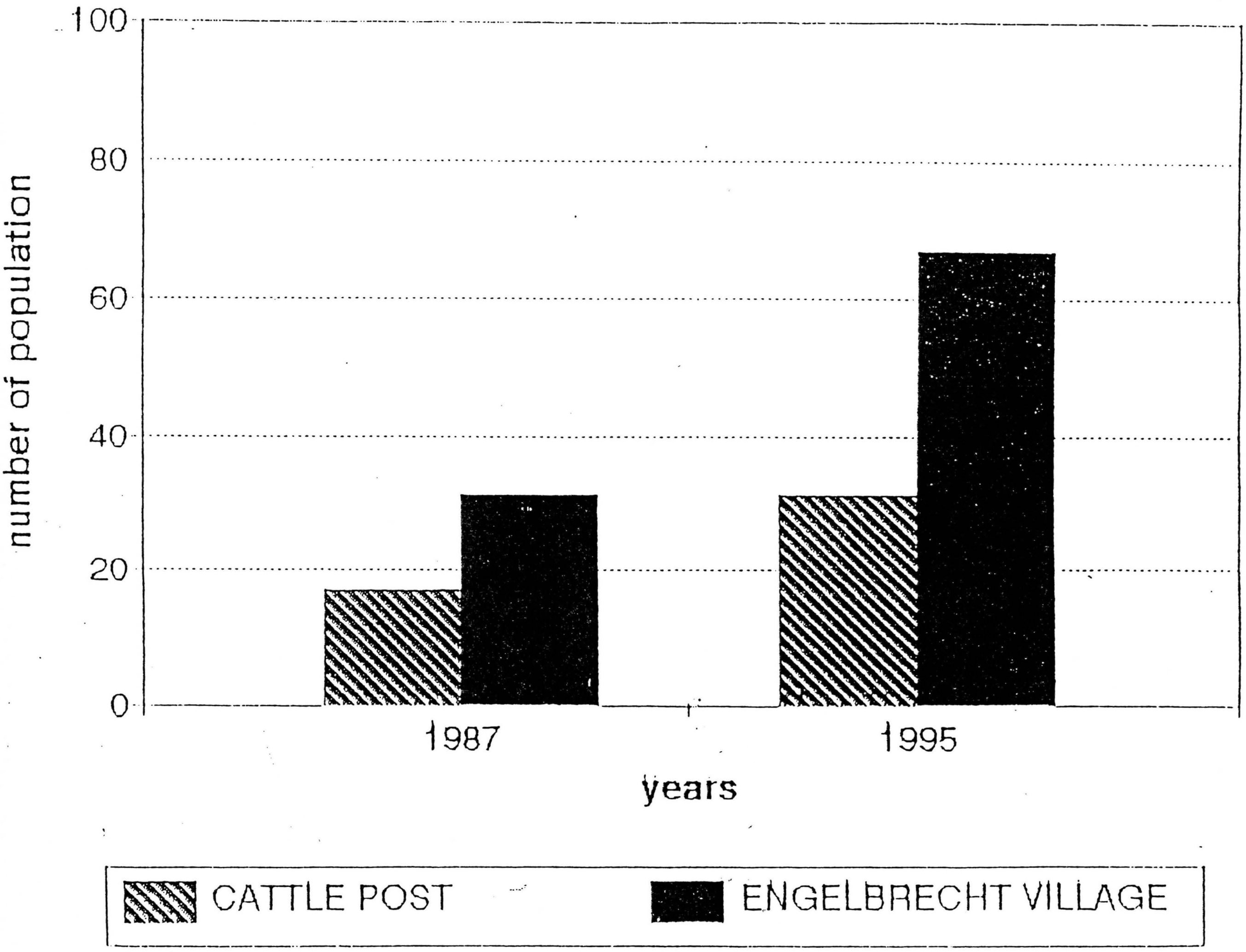
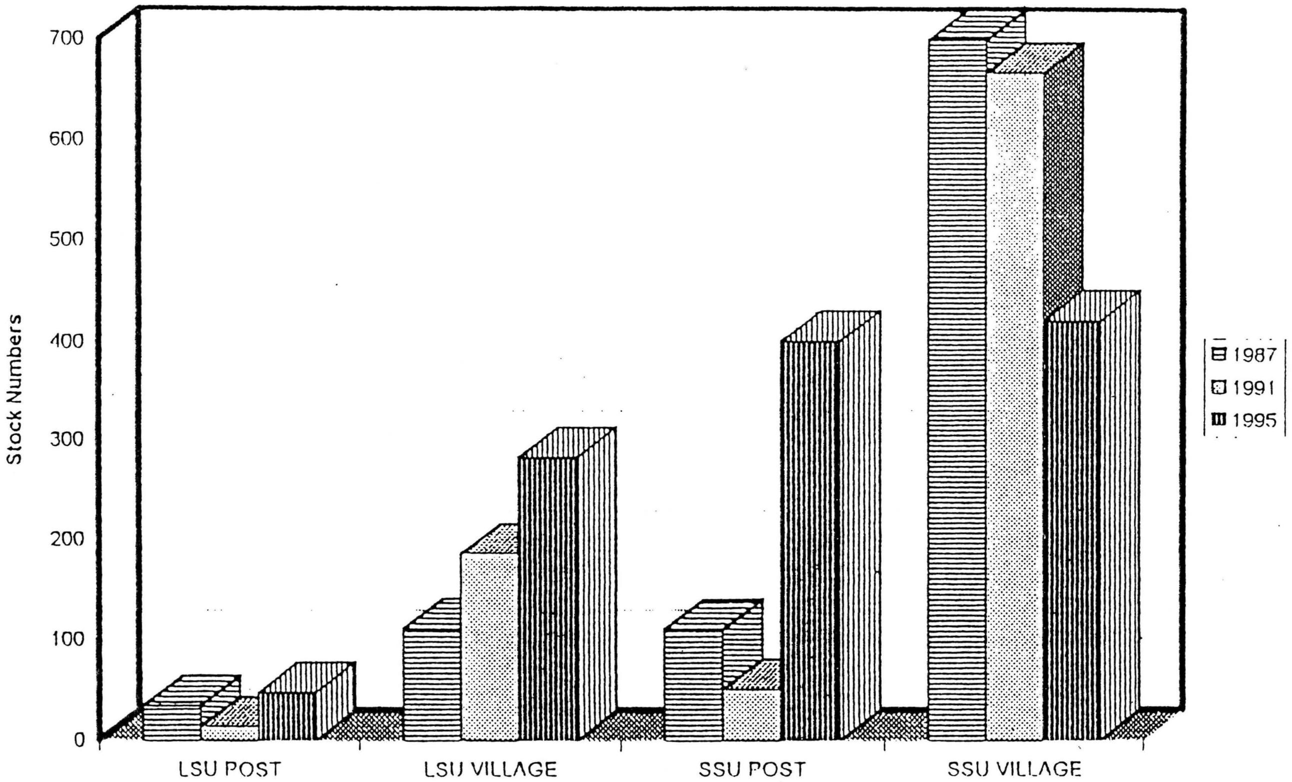


FIG.2.POPULATION GROWTH ON ENGELBRECHT.



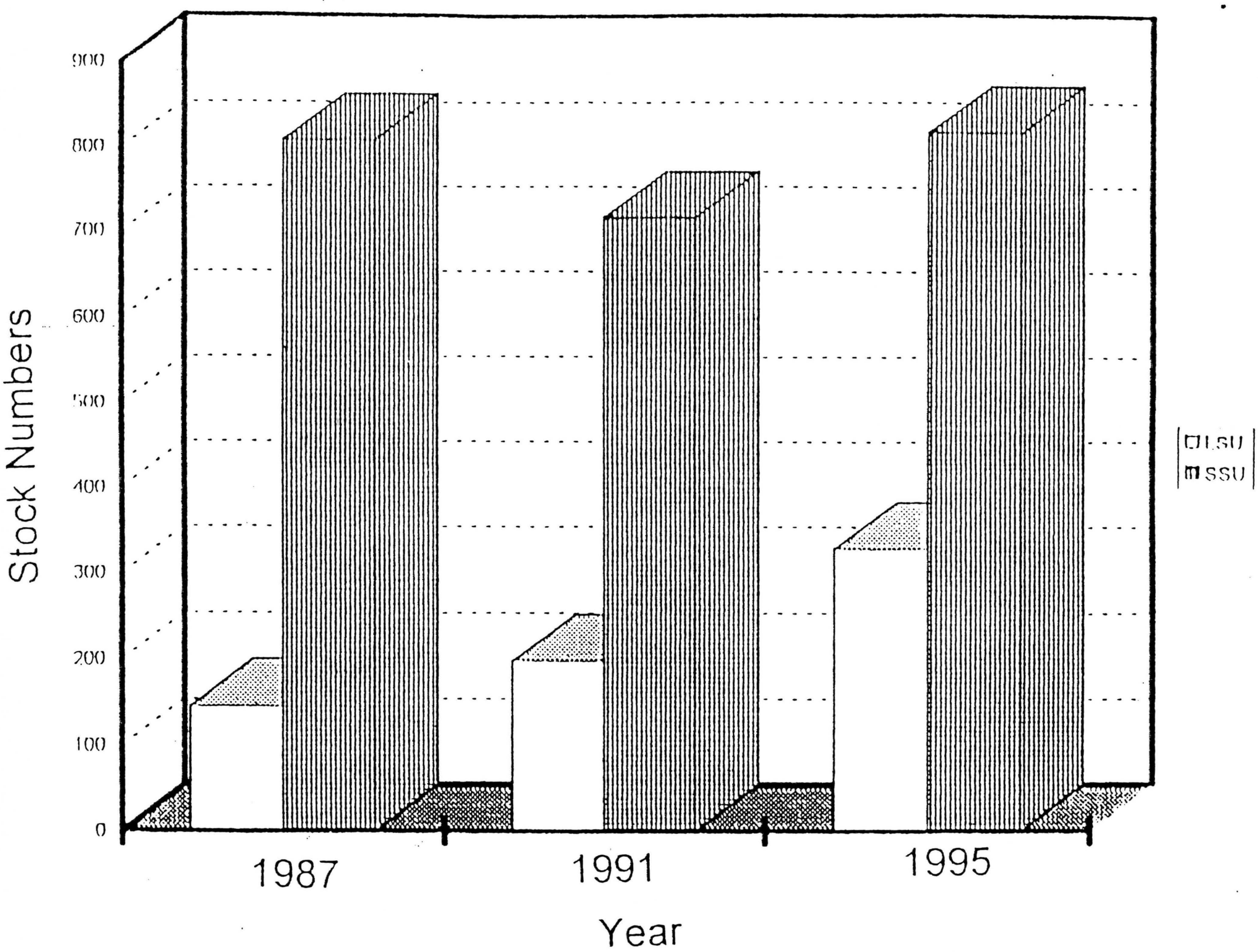
The human population at the Engelbrecht village and the Engelbrecht cattle post has increased from 1987 to 1995. During the past 8 years, the population at the Engelbrecht village has doubled.

Fig. 3a. Livestock Population on Engelbrecht over 8 years



There is a trend of increase in the number of large stock at the village with a tremendous decrease by more than a third in the number of small stock. At the post, the livestock follows the same trend of decrease in 1991, but increases again.

Fig. 3b. TOTAL LIVESTOCK NUMBERS ON ENGELBRECHT OVER 8 YEARS



number of large stock at the farm increases but the small stock remains e or less constant.

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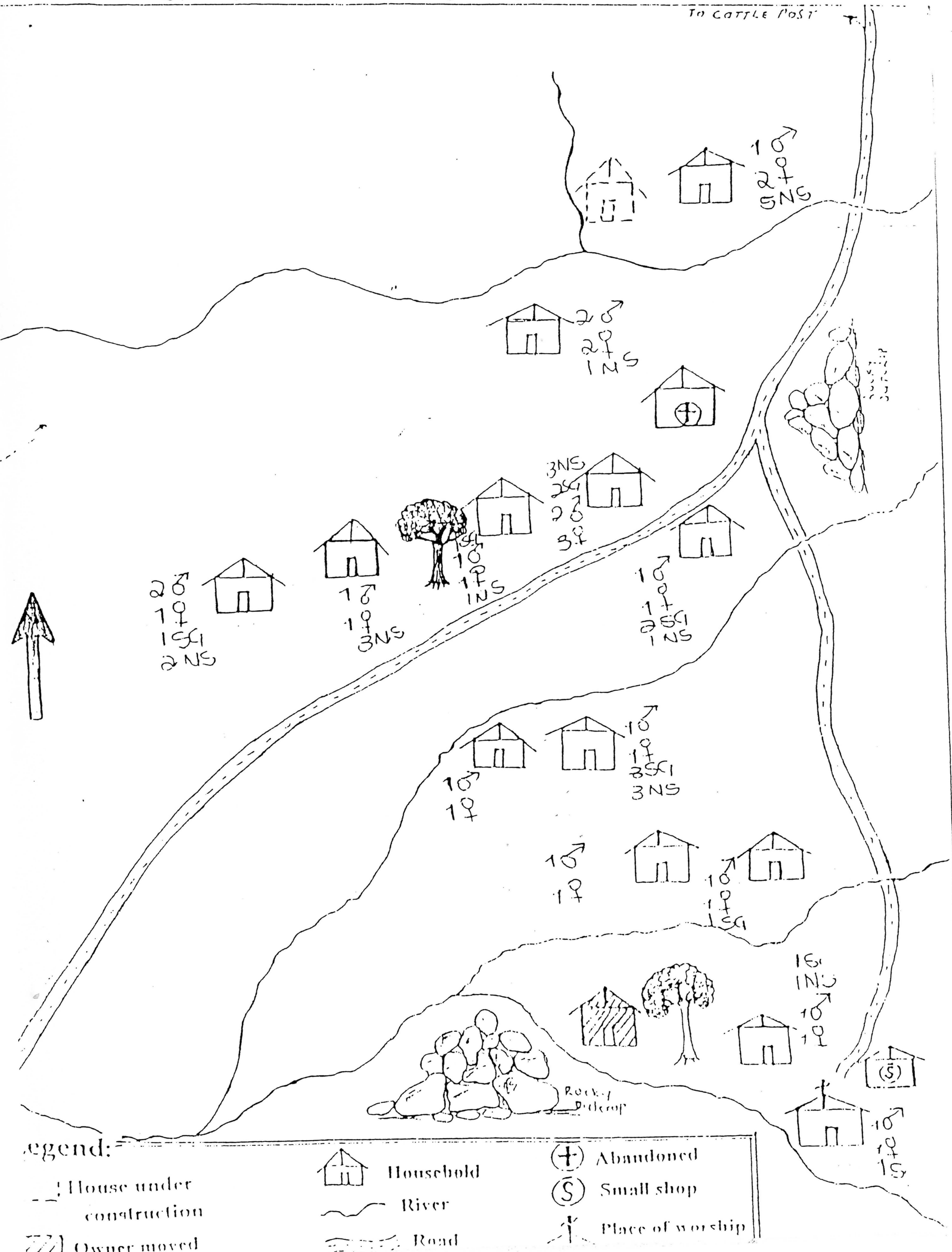
- SOCIAL MAP 1995 -

DEMOGRAPHIC CHARACTERISTICS



VALUING THE LOCAL USE OF ANA PODS AT ENGELBRECHT

I. O. Nghishoongele

Introduction

The ana pods are the fruit of the ana tree which provides animal fodder in the dry season. The scientific name of the ana tree is *Faidherbia albida*. They are harvested by humans and eaten by livestock after they have fallen to the ground in the fruiting season which is from September through December. This tree species is most important for sustaining soil fertility. It is currently under the subject of a programme of genetic conservation and rational use by the Food and Agriculture Organization of the United Nations (FAO) (Wood ,undated translation). The ana tree is one of Namibia's fastest growing trees. Although it does not grow in the southern and eastern. Namibia (see appendix, figure 1), the ana tree grows in western Namibia in areas where the water table is fairly high i.e along water courses (Craven and Marais, 1992).

The Engelbrecht communal farm, situated 50 km south-west of Kamanjab, in the Kunene Region was chosen as the study area. The farm, previously a private commercial unit which is now communally owned, has been under communal tenure since the early 1970s. Many people on the farm do not have a regular source of income apart from pensioners and those who have livestock which they can sell. Crop farming is not practised on Engelbrecht due to low rainfall and the rocky type of soil which is not suitable for cultivation as well as the alleged fear of attracting Elephants, which are fond of destroying gardens.

The aim of this part of the project is to evaluate the use of ana pods and their role as a natural resource for the Engelbrecht farm. The study aims to provide answers to questions on how much ana pods are used per household, during what period of the year they are used and what economic value can be attached to the pods and their uses? Comparison of these attributes to those of the Topnaar community along the Kuiseb river in central Namib, will be used for comparative valuation.

Materials and Methods

In order to value the local use of ana pods information was gathered through interviews, either individually or in group discussions with the local residents. A method of collecting information called the Participatory Rural Appraisal (PRA) was used. This method involves the local people in gathering the data and breaks down barriers between the local people and researchers (Social Sciences Division of UNAM, 1994). Other Participatory Rural Appraisal (PRA) tools like matrices and resource maps were also used. This participatory approach uses several methods of data collection as a way of cross-checking sources (Social Sciences Division of UNAM, 1994).

Observations were made to verify the information gathered through interviews and discussions. The ana trees were sampled for canopy cover and diameter breast height in a total distance of eight kilometres, along the Katemba River. Tree damage such as branches pulled down and the possible cause of damage, were also recorded and estimated respectively (see appendix, figure 2). The Topnaars communities at Swartrivier along the Kuiseb River in the Namib Desert were also interviewed to compare the use and value of ana pods with that of Engelbrecht. To determine the value of Ana pods to the Topnaars, different sized bags, a 12.5 and 60 kg maize meal bags, were filled with ana pods and their respective weights measured.

Results

People interviewed at Engelbrecht indicated that they collect the ana pods in bags after they have fallen to the ground. The 12.5 maize meal bag filled with ana pods weighs 1.5 kg. Some people collect the ana pods in these bags and sell them to one communal farmer nearby at a cost of N$2 per bag. Contradiction surrounds the local sale of ana pods. Some Engelbrecht residents claimed that they also sell the ana pods to one local communal farmer who has many goats, but the farmer said he had never bought ana pods from anyone. One local resident, Kavendjii, indicated that he collects a total of five bags of ana pods from two or three trees per season, leaving some behind for the livestock and elephants. The ana pods are mostly given to sick goats and lambs so that when they go out grazing they do not do it too far from the houses. The goats also browse on shrubs and trees. The villagers indicated that there was a general decline in the number of ana trees and the availability of the pods. In the Ugab catchment, commercial farmers also collect ana pods in communal areas, which appears to be a new development. In 1995, two groups of outside collectors were asked to leave the ana pods for local residents (Rudi Loutit: Chief Conservation Officer in former Damaraland and Skeleton Coast, pers. comm. via Mary Seely, 1996). Women who mostly collect the ana pods mentioned that they were willing to put their time into collecting the ana pods as long as they were there. That meant they were willing to give up N$10 which they could have earned by doing the laundry for those who have other sources of income. The reason could be that collecting ana pods and doing the laundry do not take the same time. For the Topnaars, the ana pods are the main source of fodder for their goats during the dry season. It is worth noting that some of the Topnaars also rear sheep in the arid environment of the Namib Desert which they sustain on ana pods as well. Ughos Kham, one of the Topnaars interviewed, mentioned that they collect and store ana pods, they also sell them at a price of N$15 per bag in 60 kg bags, which when full of ana pods weigh about 6 kg. They use donkey carts to travel a distance 50 km in order to sell the ana pods.

The results suggest that on the farm Engelbrecht the ana pods are not as much collected or used as it they are along the Kuiseb River by the Topnaars. The crux of the matter lay in determining the proportional amount of livestock fodder the ana pods provides to alternative pastures available at Engelbrecht. The person interviewed at Engelbrecht, being one of those collecting ana pods for goats, indicated that he collects about five bags per season which is a rather small amount for valuation. Women who collect ana pods in the same area do so and sell them to a communal farmer in another area, thus the ana pods are also a source of a cash income to the Engelbrecht community. Estimating the quantities used and attaching the price may lead to under-valuation or overvaluation of the use of ana pods on Engelbrecht farm. Owing to the limited time which was available for carrying out this project, the results warrant further investigation in order to come up with a conclusive answer. Three methods can be used for determining the price of the ana pods;

1.Local price.
2. Opportunity cost of collecting time.
3. Cost of replacements.

The nutritive value of the ana pods has to be determined in order to quantify the cost of replacements. At Engelbrecht a large number of ana trees are thought to have died because of the dropping water table caused by an increase in the number of dams up-stream and a decrease in rainfall (Jacobson at al, 1995). Rainfall in this area is also erratic and variable spatially (Rohde, 1994). It appears as if the increase in elephant population leads to an increase in elephant damage in Engelbrecht and the neighbouring areas. This again raises more questions of what should be done in order to remedy the situation. Elephant damage and other causes of damage may lead to a decrease in the availability of ana trees which would mean a decrease in productivity in livestock and game alike and would contribute to desertification of the area.

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Figure 1. The distribution of *Phaedherbia albida in Africa*

Ana tree damage in Engelbrecht area

Comparison among causes of loss

Figure 2:

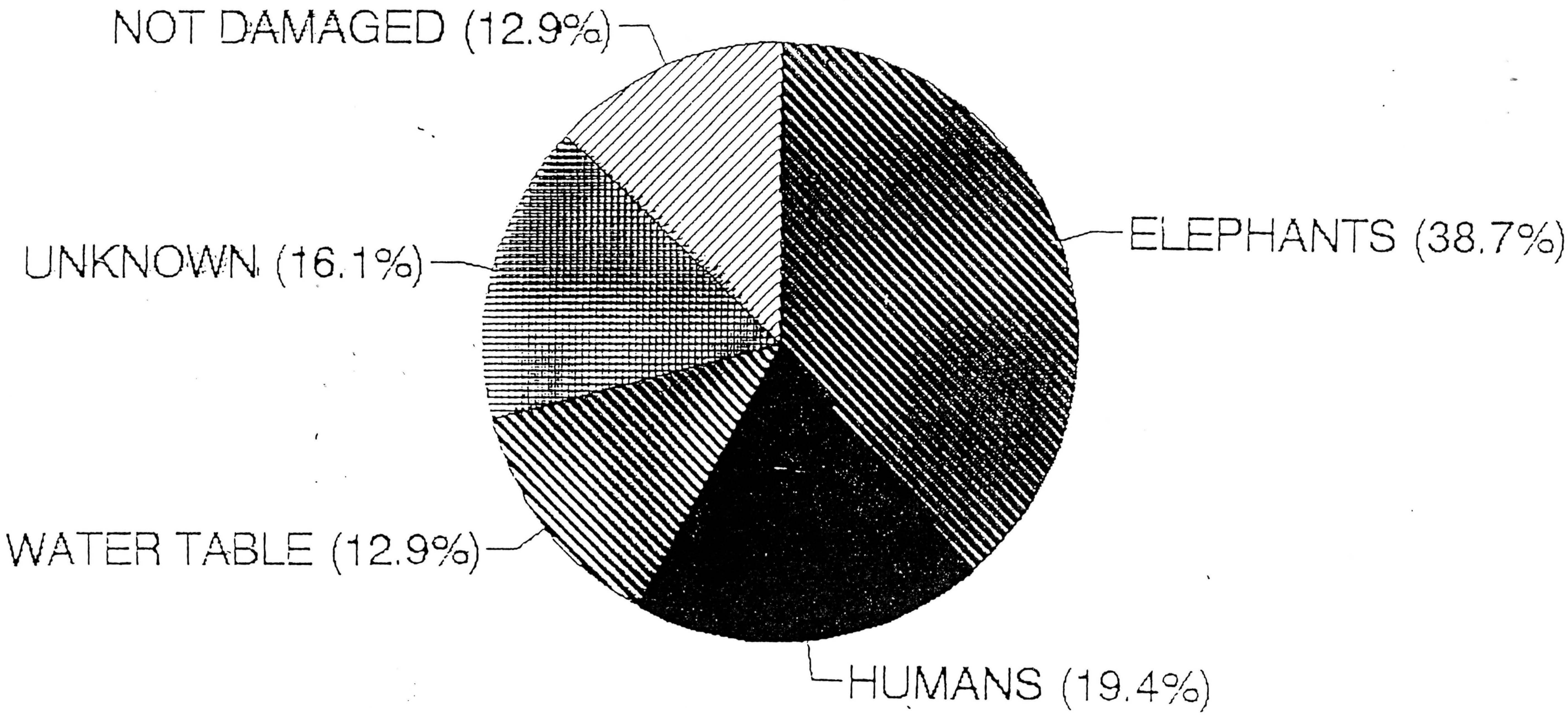

FIG. 2

ASSESSING RESOURCE MANAGEMENT ON ENGELBRECHT

Michael Humavindu

Introduction

The social trend of responding to a situation only after disaster has struck is highly undesirable in environmental issues. At stake is the kind of environment the next generations will inherit and it can be determined by today's generation's actions towards the environment (Booth et al, 1995). Land degradation is the substantial decrease in either or both of an area's biological productivity due to human interference and is an ancient problem. However it should be kept in mind that degradation is not confined to certain regions or areas only , it occurs virtually everywhere to one degree or another (Johnson and Lewis, 1995). Degradation is caused mostly by overgrazing, cultivation and poverty, and has already affected about 20% of southern African soil (Booth et al, 1994). Research on desertification should not only concentrate on the more biophysical aspects but rather, an equilibrium should be maintained by focussing on present socio-economic factors too (Stiles 1993).

Desertification or the impoverishment of arid and semi arid area ecosystems is a national concern and priority of both Governmental as well as private institutions in Namibia. A public policy on land degradation should not only promote conservation but also development, such a stand will only not benefit the local communities involved, but a wider sector of the society (Janson, 1991). Various organisations such as the DRFN(Desert Research Foundation of Namibia) in collaboration with the government have been involved in research on desertification in Namibia, thereby propagating environmental awareness, education and land management skills (Janson, 1991). This specific research was based on investigating resource management activity on a communal farm in the Kunene Region. It is a component of a research project by the DRFN to asses the possibility of desertification in Namibia.

Materials and Methods.

The research was carried out on a farm called Engelbrecht. The farm was initially commercial but is now a communal settlement. Engelbrecht is 50 km south-west of Kamanjab in the Kunene region and is 10 500 hectares in size. This study concentrated especially on resource management. The natural resources that were focused on were livestock, water, grazing area and native trees. Information was obtained mainly through PRA methods. PRA (Participatory Rural Appraisal) is a tool used in research that involves the participation of communities. It is a tool based on iterative learning, shared knowledge and flexible analysis. PRA collects information on living conditions and local situations (Keregero et al, 1992). The community and research team constructed a matrix to relate tree species to their uses and scoring was done against each tree.The use that was considered to be more important than the others got the highest score. A time budget was another PRA method used in this study to identify allocations of time to various resources.

Estimation of the water used per year was made combining human and livestock water use. The water lost due to evaporation and use by elephants was also estimated. The stocking rate allowed us to calculate the biomass of the area and therefore the carrying capacity during periods of rain and normal years. The number of mopane tree logs cleared off for house construction was also estimated. This was done mainly by multiplying the number of logs used to construct one house by the number of houses in the settlement. Finally the results were divided by average logs obtained from each tree to get the number of trees used in construction.

Results

The community on the Engelbrecht farm mainly with livestock. There are 282 cattle, 820 goats, 13 donkeys and two horses (see Kakukuru, this volume). There are 11 boreholes on the farm, of which only 4 are functioning (see Guidao-Oab, this volume). What follows is an account on the management activities of these resources on Engelbrecht.

There is little management of livestock. Cattle and donkeys are left unattended in the veld. The bulls are left to graze within the herd all year round. Goats are herded by labourers and dogs throughout the day to protect them from thieves and predators such as jackals, as well as occasionally strangling in tree branches (Ephraim Kavendjii, local resident). The little control over the movement of stock means there is little control of grazing patterns on Engelbrecht. The stock graze especially on plains and only when the area is heavily grazed do the animals graze on hilly or mountainous parts of the farm (see Guidao-Oab, this volume). Rotational grazing is not practised and reduction of stock takes place twice a year through marketing. Numbers of stock sold depend on the economic situation people find themselves in. During drought some members of the community migrate, others sell their stock and some depend on drought relief from the government (Abraham, personal comment).

People on Engelbrecht allocate most of their time preparing meals, from breakfast to dinner and doing what is termed odd jobs. The only activities that were mentioned as definite jobs apart from preparing meals were wood collection and tending to goats in the morning. The activicties mentioned take up approximately twelve hours of each day. Fifteen of the tree species in the area are used for various purposes such as food, fodder, medicine and construction (see matrix). The most commonly used tree species on the farm is *Colophospermum mopane* which serves virtually all purposes (see matrix). Firewood is collected in two different ways according to the information given by E Kavendjii. Women and children collect the wood in the vicinity of the village while the men usually go deeper into the veld (Ephraim, personal comment). This was supported by our observation of finding one cart about 5km from the village garthering wood. Our observations of one wood gathering party, however, were that men and women collected wood together near the village, using no animals. Mopane trees are used for construction all the time, but construction of houses takes place over longer periods, and the trees used are collected over a wider area. The community believes that these two factors produce less damage to the trees, although this needs futher investigation. The replacement rate of a house occurs between 3 and 5 years.

The main sources of water on the farm are boreholes. Although 1995 has had good rains, during normal times there are frequently water problems (Hosea, personal comment). The community is not satisfied with the present borehole because the pipes often fall in. Repairs are not made timeously and the community does not have the money to repair damages on its own. There are only two people who take care of water complaints and fuelling of the pump, Pastor E Eiseb and Ephraim Kavendjii. A borehole on the plains where stock graze was initially established for human use. However the pastor decided that it should be used by elephants rather than livestock and humans (Eiseb, personal comment).

Discussion.

Land degradation is caused by difficult climatic conditions and negative human activities. It is generally accepted that improving human activities may aid in preventing land degradation (Atchia et al, 1995). In Namibia this is complicated by a high population growth that doubles every 20 years (Seely and Jacobson, 1994). Proper management of the natural resources is thus called for, and should always be a priority within a community.

The community on Engelbrecht has management strategies on resources that can be termed inadequate in relation to desertification. The decision-making patterns of the community may explain the lack of proper management. Information from the community alluded to the absence of communal meetings on the farm. Thus, decisions are taken mainly by two people, for the interest of the whole community. Even during periods of drought there are no emergency meetings. Each family decides what to do on its own and community inter-action and co-operation are weak. An appropriate example is that having camps is preferred by the community. Still some people are just waiting for others to accomplish that goal (free-rider problem) (Ephraim, personal comment). Participation of local people in decision making concerning natural resources is vital for resource management to succeed (Esser-Winkler, 1993). Common property resource management fails partly due to weak decision-making patterns (Gupta, 1985). Figures 2 and 3 clearly show that the stocking rate after periods of rain almost doubles in comparison to the normal period and that during normal times the number that can be sustained is relatively low. This is a sign that warns against overstocking during normal times.

Another example is the way wood is collected on the settlement. Men are supposed to collect wood further away from the village, since they use transport, but the research team came upon men with a donkey cart collecting wood, not even 200 meters from the village.

The time budget as depicted in the activity clock is biased as it was drawn up by a group predominated by women. Consequently, major activities which are directly linked to resource management, such as collecting wood, mending fences and cutting trees, which are performed by men, are missing from the list. One other limitation is that the activity clock highlights daily activities, thus omiting activities that may take place once or twice a year, but which are crucial to resource management, such as auctions, drilling boreholes or moving stock during drought. Another obstacle to proper management is transport and current market prices. These factors determine the stock sold on the market during drought. The reduction of stock becomes a vital management strategy during drought, since the more stock that are sold, the less pressure is put on the land.

On the other hand, transport costs are high and most of the income from selling the stock is used to covers these costs. This may cause selling to be a financial burden rather than a means of deriving an income for the farmer. When the cost of selling stock surpasses the returns derived from selling them, it may act as a disincentive to sell. As a result of that, the community sells less stock than desired and holds on to the rest. In addition, the community will only sell the livestock that are older and badly affected by drought, thereby reducing the price fetched on the market. Even if a subsidy is organised as an incentive to de-stock it hardly makes up for the low prices brought about by the poor condition of the stock (Rohde, 1995).

Some of the problems that the community encounters with resource management are experienced worldwide. The variability of prices and supply are two fundamental problems of livestock marketing (Scoones, 1995). The number of livestock sold depends also on the size of the herd (Scoones, 1995). The number of stock owned by families on Engelbrecht shows that the herd size is not big. Except for one family that owns more than a hundred cattle, the rest have cattle ranging between 5 to 15 in a herd (see Kakukuru, this volume); the smaller the herd size, the less the initiative to sell.

A commonly mentioned problem on the farm is elephants. Elephant activity is perceived as an obstacle to proper resource management. The activities of elephants includes damage to fences and trees making it impossible to practise rotational grazing. During colonial times the previous owners of the farm controlled the elephants numbers through culling (Hosea, personal comment). Each morning fences were looked at and any damage repaired (Hosea). The existing laws of the country do not allow for such practises any more. The elephants not only discourage fencing, but also gardening. One villager tried gardening some time back and elephants destroyed his efforts (Hosea). Information on actual or perceived costs of elephant activity could not be provided.

Elephants are a common problem but they are also seen as a potential income provider. There are opportunities to use elephants in order to generate income that can assist the community to repair broken boreholes and fences. The NGO(WWF) that was running the elephant borehole has left the settlement. There are paintings on certain rocks that can be used as a tourist attraction. Pastor Eisch was considering turning the painting site into a tourist attraction, although the lack of financial resources is holding him back (Pastor Eisch, personal comment).

Although the resource management activities on Engelbrecht can be termed inadequate in relation to land degradation,there are some actions that are desirable. Pastoral development in most part of Damaraland is hampered by factors such as scarcity of water, grazing resources, droughts and increased population pressure (Rohde, 1995). Water is one of the scarcest resources in Namibia and needs to be managed effectively (Ashley, 1994). This is supported by figure 1 which estimates the amount of water consumed in a year. The figure clearly shows that the community and their livestock are the primary consumers of the water available. But most of the boreholes have dried up, probably due to a drop in the water table. The drop in the water table may be related to the fact that farmers have built dams upstream in the catchment area. These dams may block or reduce volume of water reaching downstream (see Kakukuru, this volume). This situation is also being experienced by the Topnaar community who lives in the Kuiseb Catchment Area in Erongo region (Dausab et al, 1994).

Proper resource management on Engelbrecht may be hampered by lack of community organisation and elephant damages but the farm population demographics (see Kakukuru, this volume) clearly points to another potential factor, manpower. There are few young and capable men to mend fences and herd stock as most influential men are relatively old. Only two young men were found on the farm during the course of the fieldwork, of whom one was just a visitor. The other young man, Abraham, seems pre-occupied with managing elephants. Though each household was indicated to consist of a man and a woman, only women, mostly old ones, and children were found on the farm. Most young men are probably employed on adjacent farms, towns or looking for jobs. This problem may be complicated by the frequent absence of the apparently sole decision maker from the farm. The presence of such obstacles makes proper resource management virtually impossible. However, there are some thoughts and actions from the community that are desirable for effective resource management.

The absence of a water committee does not completely decrease the community's influence on the construction of boreholes. Although rural communities lack financial resources, development projects such as tourist attraction should be a local initiative. A country such as Botswana has tourism activities that are founded on a local level. Tourism benefits local communities by providing jobs and income (Pfotenhauer, 1993). This is also the case in Zimbabwe where large mammal such as rhinoceros are utilized in tourism to the advantage of the community (Moyo et al, 1991). Rural communities should be educated about various alternatives resource management strategies and the value of the natural resources found in the area (Ashley, 1994). If such strategy is applied, the community should decide on how these resources should be managed. The most important thing is that resource management should be a community effort and not an individual one.

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Appendix. 1

CALCULATIONS

ESTIMATES OF ANNUAL WATER USE AT ENGELBRECHT (Fig.1)

Number of people: = 98

Estimated daily consumption. @ 25 l/persaon/day

=2450l/d

Number of cattle: = 282

Estimated daily consumption: @ 40l/ LSU/day

=11280l/day

Number of goats: = 820

Estimated daily consumption @ 10l/SSU/day

=8200l/day

Number of donkies: = 13

Estimated daily consumption @ 27l/LSU/day

=315l/day

Number of horses: = 2

Estimated daily consumption @ 27l /LSU/day

=54l/day

Total daily water consumption 22219l/day

Total water use per year 8109935l/year

ESTIMATES OF WATER USED BY ELEPHANTS (Fig.1)

Number of Elephants in the vicinity = 81

However elephants are sighted after every fourth week. Sometimes they are seen on the farm but do not drink there or they come in at night and drink. Other times it's only a bull or two that has wandered off that is seen. Normallly the elephants stay on the farm for a day. As an estimate 81 elephants are taken to consume water on the farm, two times in a month, or 24 times in a year.

An elephant consume @ 234l/day

They drink between 2 and 4 times a week (Kisangani 1986).

81 x 234l/day x 24 = 4548961 /year

ESTIMATES OF WATER LOSS TO EVAPORATION

The evaporation rate = 3000mm/year

Daily evaporation rate = 8mm/day

Water lost to evaporation is estimated through the use of two open tanks on Engelbrecht.

Average radius of the tanks = 4m.

Area of tank = pr^2, where p=3,1416

$3{,}1416*(4)^2=50{,}2656m^2$

Volume lost: = $50{,}2656m^2$ X 3m/day =$150.797m^3$

$1m^3$ =1000l

Lost to evaporation 150,797l/day = 15079711 /y

PERCEIVED THE STOCKING RATE (Fig.2)

These are values on the stocking rate on Engelbrecht,as perceived by the community. The size of the farm is 9200ha. Stocking rate after period of rain:

cattle: 600 :9200\600=15,3ha/LSU(large stock unit)

goats:800 :9200\800=11,5ha/SSU(small stock unit)

Stocking rate during normal times:

cattle:300 :9200\300=30,6ha/LSU

goats:500 :9200\500=18.4ha/SSU

BIOMASS BASED ON THE STOCKING RATE

The livestock biomass shows the relative percentage of cattle and goats that the available grazing area can support during periods of rain and normal times. The average weight of cattle is estimated at 500kg. The average weight of goats is estimated at 80kg.

Biomass in normal times:
cattle:300 *500kg = 150000kg
goats:500 *80 =4 0000kg
Biomass after periods of rain:
cattle: 600 *500kg = 300000kg
goats:800 *80 = 64000kg

ESTIMATES FOR HECTARES CLEARED OFF IN CONSTRUCTING

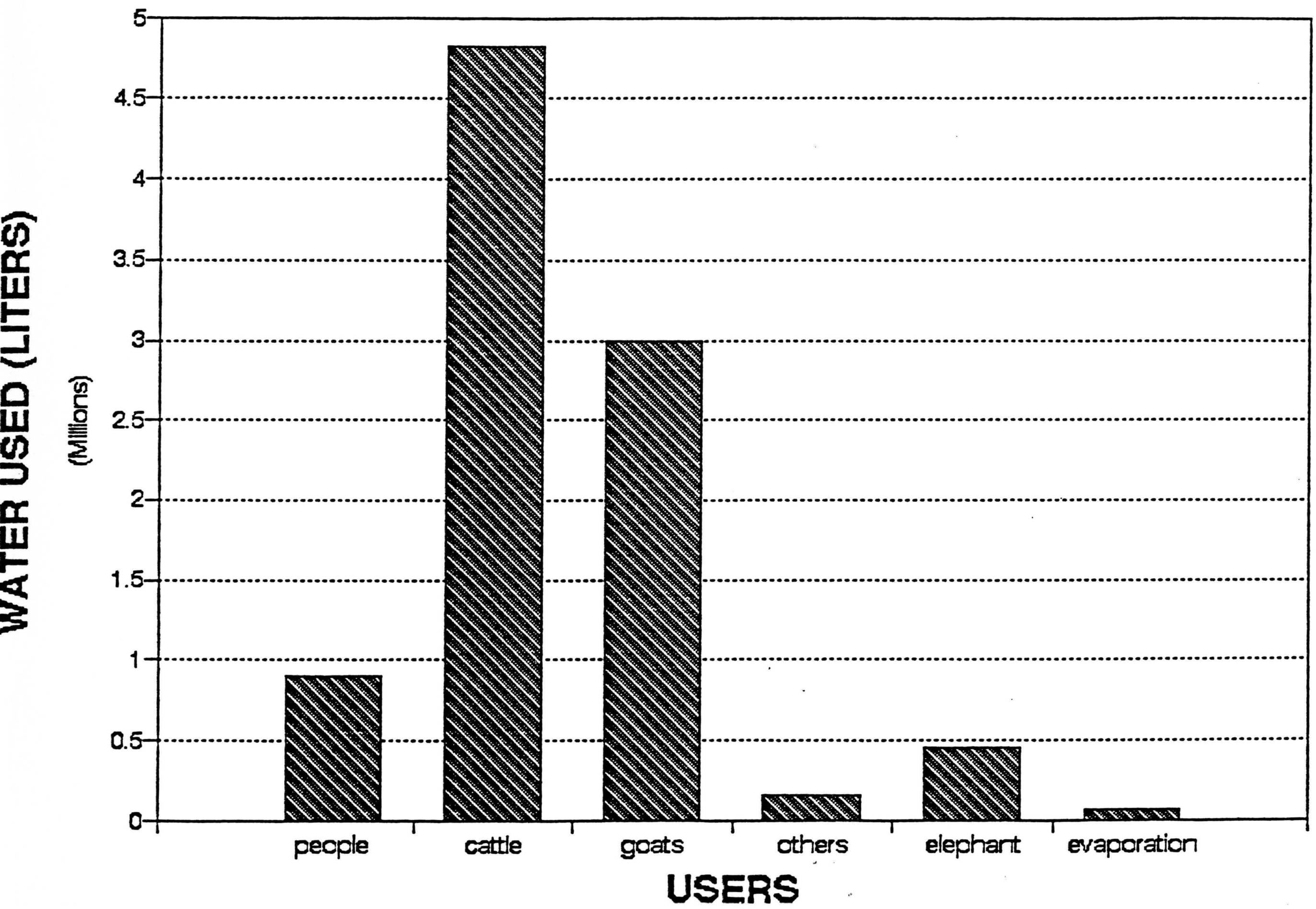
HOUSES USING MOPANIE TREE DENSITY/HECTARE

Mopane trees are the most common trees used in construction (as shown in the matrix). The density of mopanie is 2,15 trees per $100m^2$

Per hectare there are 215 trees/ha (see Ngololo, this volume). On average 278 logs are used to construct a house with estimate of 5 logs per tree.

:278 x 13(number of houses) = 3613 logs :3614 logs\5 logs\tree = 773 trees :773 trees\215 trees/ha = 3.5 ha cleared off. The replacement rate of a house is between 3 and 5 years.

FIGURE.1.TOTAL WATER USED PER YEAR ON ENGELBRECHT FARM



The grah presents the total estimated water consumed by the people, livestock, elephants as well as water lost by evaporation. Such information is necessary in periods of drought, thereby knowing exactly which livestock to reduce in order to save water.

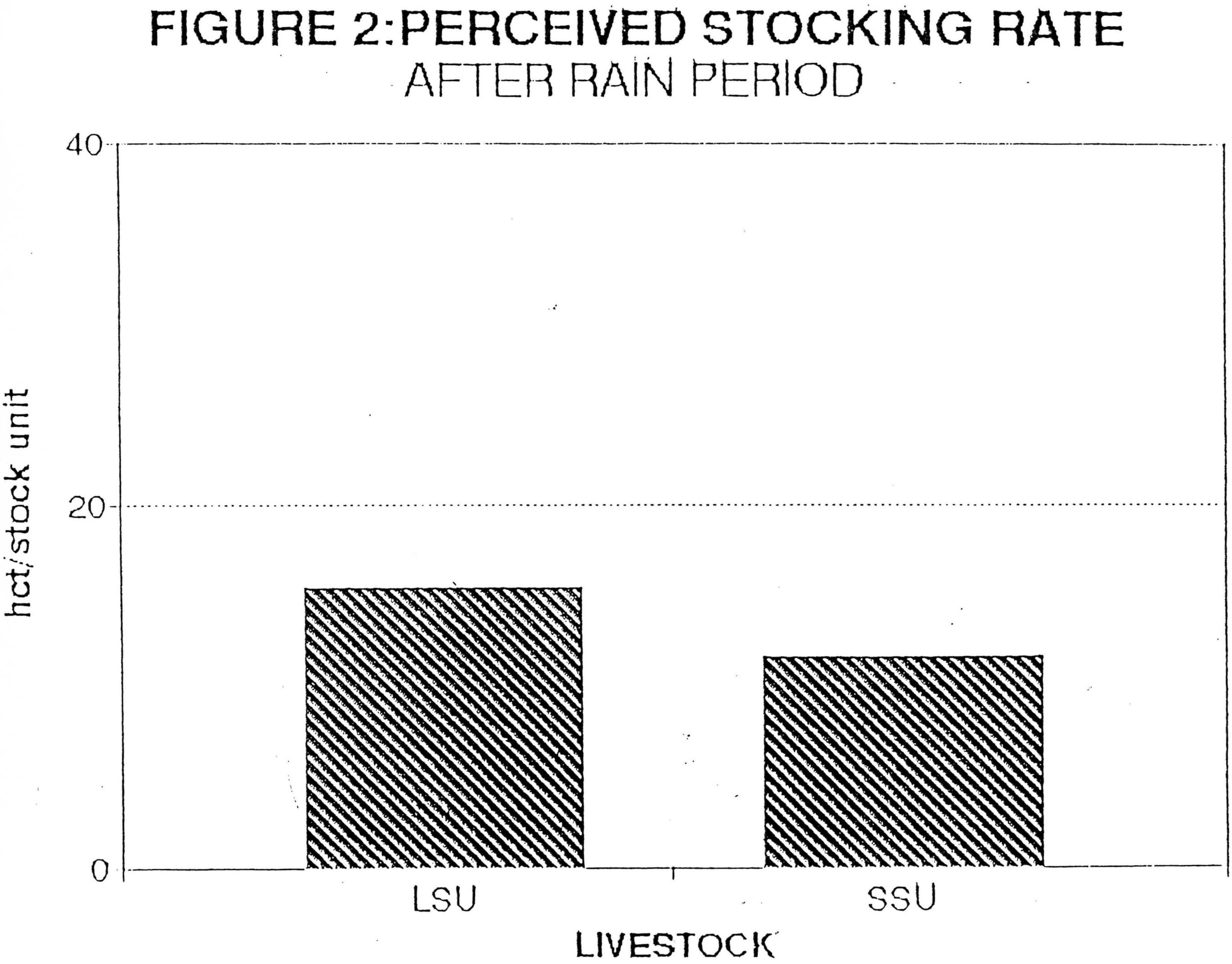


Fig. 2 The stocking rate was calculated according to the community's estimates on the number of livestock that can be sustain after a rainy period. After a rainy period 17.5 ha can sustain one large stock unit (LSU), while 13 ha are needed to sustain one small stock unit (SSU).

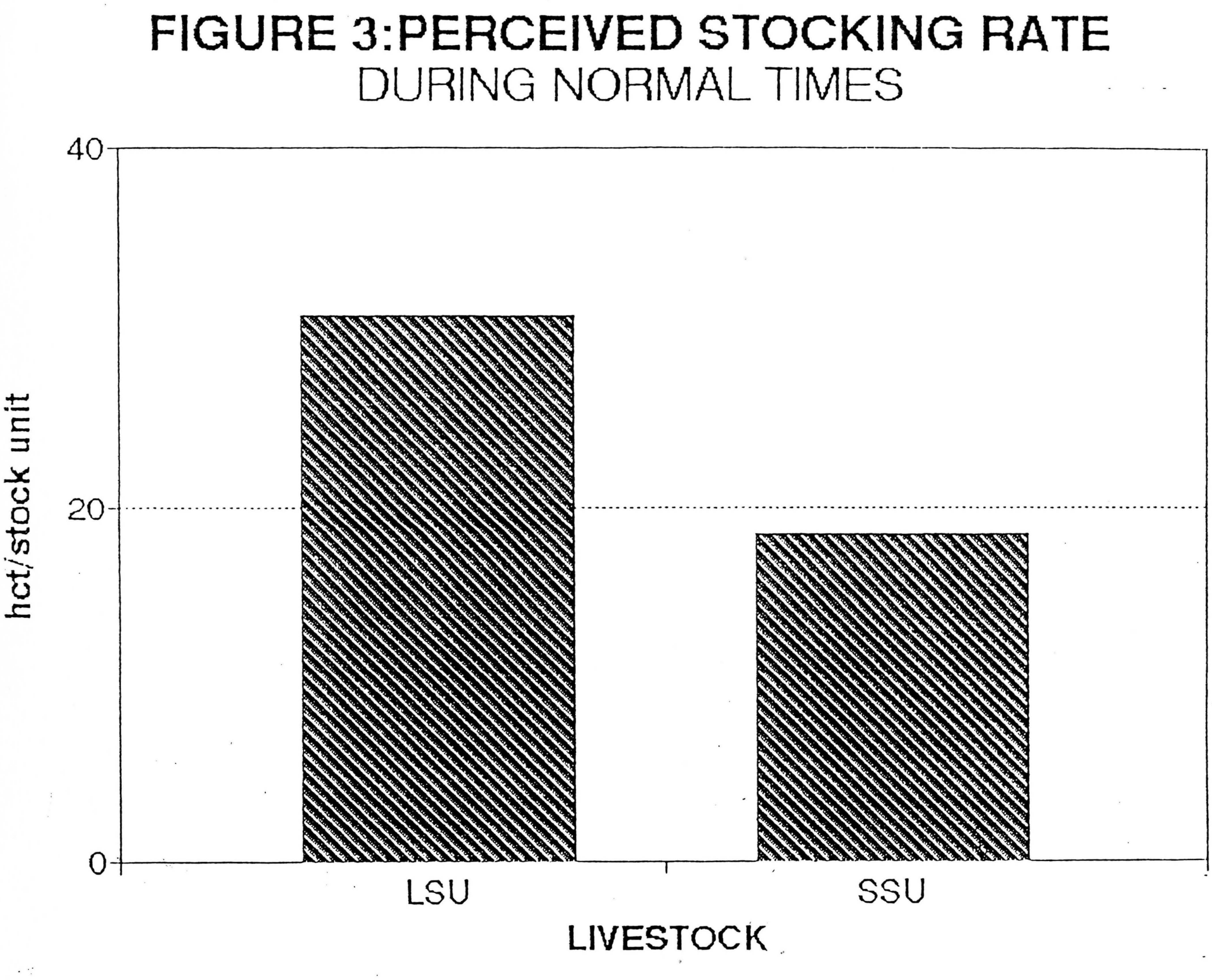


Fig. 3 The stocking rate was calculated according to the community's estimates on the number of livestock that can be sustain during a normal period. In normal times 35 ha can sustain one large stock unit (LSU), while 21 ha are needed to sustain one small stock unit (SSU). During normal times much more land is needed to sustain one livestock, therefore overstocking will lead to overgrazing.

FIGURE 4:BIOMASS ESTIMATES FOR STOCK
AFTER GOOD RAINS

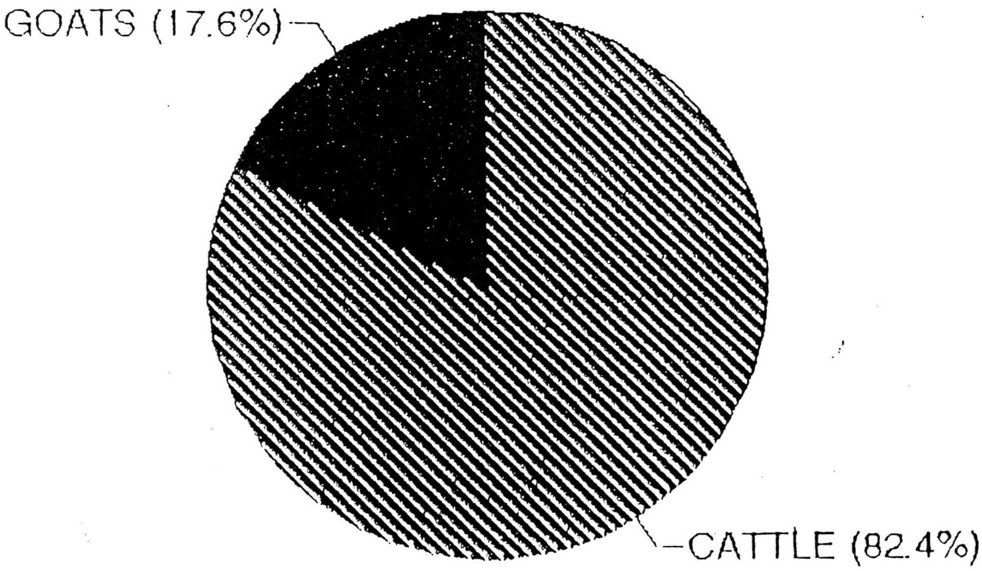


Fig. 4 The livestock biomass shows the relative percentage of cattle and goats to periods of rain and normal. Cattle was estimated at a weight of 500 kg per cow, while goats were estimated at a weight of 80 kg per goat. During periods of rain the livestock biomass has 82.4% cattle and 17.6% goats. The total weight of cattle was 300 000 kg and goats total weight was 64 000 kg.

FIGURE 5:BIOMASS ESTIMATES FOR STOCK
DURING NORMAL TIMES

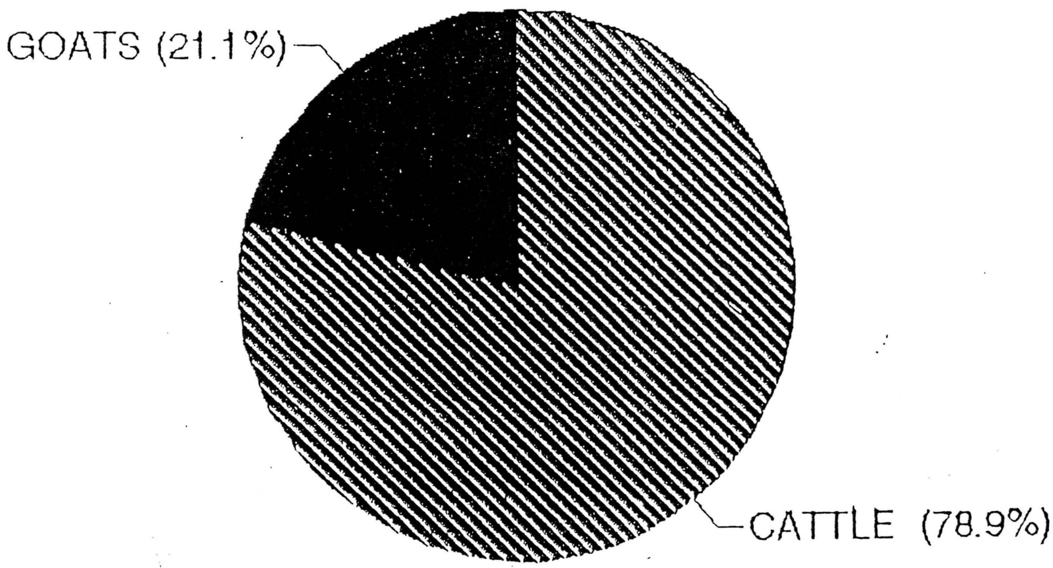


Fig. 5 The livestock biomass shows the relative percentage of cattle and goats to periods of rain and normal. Cattle was estimated at a weight of 500 kg per cow, while goats were estimated at a weight of 80 kg per goat. During normal times the livestock biomass is composed out of 78.9% cattle and 21.1% goats. The total weight of cattle is 150 000 kg and 40 000 kg is the total weight for goats.

FIGURE.6.: A TREE MATRIX

USES OF TREES

LOCAL NAME	SC. NAME	FOOD	FODDE	CONST	CARVE	FUEL	MED.	WAT
/UNIS	B. ALBITRUNCA	xxxxx	xxxxx				xxx	
TSAURA-HAIS	C. MOPANE	xxxx	x	xxxxx	x	xx	xxxx	
‡OS	A. DESERTORUM	x	xx	x	x	x	xx	
ǁA-NAS		x	xx	xx		xxx	x	
‡HEAS		x	xxx	xx	x	xx	x	
ANA-HAIS	F. ALBIDA	xxx	xxxxx					
KORA-CHAS		xx	x				xx	
!HAU-OAB		xxx	xx		x			xxx
/NA-RAS	A. HORRIDA	xxx	xxx					
!HAS				xx	x	xx	x	
!NOES		xxx	xxx	x		x	x	
TSA-BIS	E. PSEUDEBENU	xxx	xxx			x		
KHORIS	S. PERSICA	xxx	xxx					
DU-HAIS		xxxxx	xxxxx	xx	x	xxx		
XAU-BES	B. FOETIDA		xxxx					

Fig. 6 A matrix was constructed by the research team and the community in order to identify tree species and their value and use to the community in the area. Scoring was done against each tree's uses and the use that was considered more important than the others got the highest score.
NOTE: fodde= fodder, const= construction, carve= wood carving, med= medicine and wat= water.

CHANGES IN WOODY VEGETATION WITH INCREASING DISTANCE FROM THE WATERHOLE

Elizabeth Ndeukumwa Ngololo

Introduction

Desertification is defined as land degradation in arid to semi-arid environments (Cardy, 1993). It may result in reduced human and animal carrying capacity. The causes, processes and symptoms accompanying degradation of land are multiple, complex and related to other global processes that are not easy to dissect (Seely et al, 1994). The environmental indications generally associated with land degradation range from biophysical soil characteristics such as nutrient loss, erosion and salinization to social ones such increasing poverty (Shanyengana, 1994). However, the formalized UNDP (United Nations Development Programme) definition of desertification alludes to the loss of productivity as the ultimate consequence of land degradation. Loss of productivity may imply different things to different people and can be defined on the basis of either agricultural output (livestock or crops) or economic output. Nevertheless, the most tangible means of measuring productivity is via measuring primary productivity, which is vegetative output of plants.

Changes in plant biomass production is not easy to determine as it may require long-term monitoring and measurements. However, plants are known to produce distinct morphological features and deviations from general growth habits in response to sustained herbivory pressure (Mueller-Dombois and Ellenberg, 1974). These characteristics can be measured within a relatively short time and deductive conclusions can be drawn from these trends to explain observed or perceived phenomena.

A commonly known process in the progression of land degradation is the deterioration of vegetation cover around watering points. As livestock tend to spend more time in the vicinity of waterholes, they trample, graze and browse vegetation extensively near the watering point. This causes a pattern of gradual increase in vegetation with increasing distance from the waterholes. These differences caused by the impact of herbivores on vegetation may in turn induce different responses from the vegetation which may be translated into different morphological features (Young, 1986).

Woody vegetation is more prone to eventual herbivory because it is usually present in an area for longer periods than herbaceous vegetation and would be expected to produce more profound responses. As a result, woody vegetation would depict varying conditions of land degradation with distance from waterholes through secondary morphological adaptations to browsing. This applies specially to thorn bearing trees (Ward pers. comm.).

In most African rangelands where the principal farming practice is rearing livestock such as cattle which are selective grazers, the pressure is mostly on grasses rather than on woody vegetation. A consequence of such heavy grazing pressure is often an increase in woody vegetation which may replace the grasses, a process known as bush-encroachment (Kambatuku, 1994). It is commonly assumed that at any particular site, the habitat is supporting the maximum possible density of trees and thus the position of surviving individual plants is determined by competition for moisture between individuals (Greig-Smith and Chadwick, 1965). A bush-encroached area, therefore, will be expected to have woody vegetation growing much more densely in a thicket compared to a natural savanna ecosystem where a balance is maintained between trees and grasses (Storhbach, 1991). Hence, tree density can serve as a reliable indirect measure of the magnitude of grazing pressure experienced by grasses in some areas at some rainfall levels.

The particular project we investigated focused on the description and analysis of morphological differences in woody vegetation as well as their spatial distribution and densities, as a function of distance from waterholes. It is hypothesized that the vegetation closer to the waterholes would produce more side branches per branch-length on which longer and more numerous thorns would be borne. Such a feature was expected to go along with the production of fewer and smaller leaves embedded amongst the thorns as a strategy to minimise browsing. Fewer and smaller leaves would result in reduced photosynthetic activity and thus diminished productivity, which would be partially compensated for by greater growth of branch tips and more side branches. Moreover, trees may grow more densely closer to waterholes than far away, where grazing would be minimal.

Materials and Methods

The study site chosen was Engelbrecht, a former commercial farm and now a communal settlement 50 km south-west of Kamanjab in north-western Namibia. This area lies within an arid part of the country where there is very low annual rainfall and high evaporation rates are the most prevalent climatic features (see Nghitila this volume). The rain that fell in early 1995 was in fact the best to be recorded in the area for the past two decades (Eiseb, Pers. Comm, Weather Bureau records). The area is classified as mopane savanna (Stols, 1994). Mopane *(Colophospermun mopane)* is prominent there although trees of other species such Combretum species and Terminalia prunoides are also present.

Of the eleven waterholes found on Engelbrecht, four are in use and two served as the focal points for the study around the waterhole.The one waterhole, herein referred to as waterhole 1 (19^0 56' S , 140 41' E) close to Engelbrecht village, is used by humans, goats and cattle. The second waterhole, referred to as waterhole 2 (190 57' S, 140 41' E) is said to be used by elephants (see Guidao-oab, this volume).

A 250 m transect was measured southwards from waterhole 1 and quadrants placed along the transect at intervals of 50 m. Another two sites were selected 500 m and 1000 m eastward from this waterhole. At both sites, a central point was chosen from which three quadrants in different cardinal compass directions were established. The same method was followed in establishing sampling sites at waterhole 2, 500 m and 1000 m from it. However, no short distance was laid out at this waterhole as at waterhole 1, but sites were selected 50 m from the waterhole at 0, 120, 240. A total of seventy six quadrants were sampled; forty at the waterhole 1 and thirty six at waterhole 2.

At each quadrant, the closest woody plant to the central point in each of four cardinal directions was selected and its distance measured and recorded. The inverse of the distance of plants from the central point of a quadrant served as a measure of tree density in each site (Mueller-Dombois and Ellenberg, 1974). The heights (rounded to the nearest 50 cm for trees) and the trunk circumferences at breast height of 1.5m(to the nearest 1 cm) of the trees were measured and recorded to indicate their size distribution. A branch whose tip was within 1.5m of the ground was chosen at random from each tree and its length measured. The 1.5m height ensures that the branch is within the range of heights that goats can reach when standing on their hind legs. The last 50 cm of the branch was measured and the number of thorns, the number of leaves, the lengths of ten randomly chosen leaves, the length of new growth of the branch tip and the number of side branches within that 50cm were recorded. The percentage of dead material of each tree was estimated and recorded.

Analysis Techniques

We tested whether there were differences in the percentage of dead trees with differing distance from the waterholes, using ANOVA (Analysis of Variance) (Krebs, 1989). In order to obtain an unbiased measure of tree sizes, we used PCA (Principal Component Analysis) of the following variables : tree height, canopy diameter, side branches, leaf number and leaf size. PCA is used to investigate the links between the weightings of the variables (Orloci et al, 1979). Tree density differences between sites 100m, 500m and 1000m away from the waterhole were analysed using ANOVA. The sizes of all trees between sites were compared using the Kruskal- Wallis test, which was also used to compare sizes of mopane trees. ANOVA was also used to compare thorn lengths.

The Sorensen index of similarity was used to determine the similarity in species between all pairs of sites (Krebs, 1989). This index is $S = 2j/a + b$, where j = the number of shared species , a = number of species at site a, b = number of species at site b. In addition, we measured the similarity among sites using a cluster analysis of species abundance (Mueller- Dombois and Ellenberg, 1974). This technique uses species density data obtained from the point quarter technique mentioned above.

Results

There are differences in communities around each site, meaning that each sampled quadrant contained different tree species. The points (distance from the waterhole) are not shown as single individuals on the graph (fig. 4) but rather as paired clusters linked together at certain levels of similarity (Mueller-Dombois and Ellenberg, 1974).

The overall measurement of tree sizes was obtained by using PCA. The mopane trees within 100m from the waterholes were significantly smaller than those found at 500m and they decreased slightly (but not significantly) in size at 1000m (fig. 1).
The same method was used for all trees. The weightings of tree was done to obtain the overall measurement of tree size. The ANOVA test of the variables previously mentioned gives the following results : $F=3.617$, $P=0.049$, Error d.f. = 17. There is a difference in the size of trees within 100m between two waterholes. The trees at 500m were the largest and a decrease in size of trees at 1000m was observed (fig.2).

The Acacia species mainly occur at 1000m away from waterhole 1. These are primarily : *Acacia mellifera, Acacia erioloba* and *Acacia erubescens*. There was no significant difference in the length of thorns of the Acacia species when all species were combined, near and far from the waterhole (fig. 3).

The length of branches of trees close to the waterholes were longer than trees far away (intermediate SE = 0.765) using ANOVA. There was no difference between branch lengths at 500m and 1000m (fig. 6).

All trees exhibit an equal degree of dead material, due to either animal damage or natural death, so that the percentage of dead material on trees were in the same range regardless of their distance from waterholes. The differences in percentage of dead trees was not significantly different between trees near and far from the waterholes (fig. 4).

Discussion and Conclusion

The term plant communities as used in this study, refers to a distinctive sub-division of vegetation cover. Wherever the vegetation cover shows obvious spatial changes, one may distinguish a different community. These changes in growth or morphology of plants may be due to responses of the vegetation to environmental conditions, which in turn may produce different properties (Mueller-Dombois and Ellenberg, 1974).

The method used was specifically designed for the Acacia species (Ward, pers. comm), which were only found clustered at a distance of 1000m from waterhole 1. This could be attributed to the level of high accumulation of silt, less sand and also the fact that there was a dry stream in the area (Roodt, 1992). The dominance of the mopane species is ascribed to the fact that it is more tolerant of well-drained soils (Roodt, 1992).

The thorns of the *Acacia erioloba* are generally expected to be longer and more numerous near and far from the waterpoint due to browsing activities (Ward, pers. comm.). The same study was done in Israel with the Acacia species and also along the Kuiseb river with the *Faidherbia albida* (Ward pers. comm.). The outcomes of both studies were that the trees closer to the waterhole had longer thorns (fig. 3). Young (1984) reported that longer thorns are induced by large mammal herbivory on the *Acacia depranolobium*. He compared trees from an unbrowsed community to trees exposed to browsing activities.

Thorns on browsed branches within the reach of goats were significantly longer than thorns from higher branches on the same browsed tree, and significantly longer than branches at similar heights on unbrowsed trees .

The length of branches could be an adaptive development by the vegetation to increase the total surface area of side branches and thorns (fig.5). The reverse is true in the overgrazed area (see Ngarirorue in this volume) around the waterhole 2. Grass, when present after good rains, offers an alternative source of food to potential browsers like elephants which would then spare the woody vegetation.

Increase in human population in semi-arid and arid areas leads to a corresponding increase in livestock holdings and therefore the deterioration of the range (Cumming, 1982). Herbivores have major effects on the plants they consume and the character of these effects depends on factors such as feeding preferences, differential growth rates and competition among co-occurring plants (Louda, 1990). The influence of browsers on vegetation changes are more likely to be greater within the immediate vicinity of a waterhole due to livestock converging from all directions, in the absence of camp fences, on a waterhole. Livestock tend to concentrate in bigger numbers around the waterholes and hence trampling, browsing and impact on trees is increased there (fig. 1 and 2). The biggest trees were found at 100 m, after which tree size started decreasing probably due to a magnitude of factors not easily explained by this type of study (e.g. soil and heavy browsing). Another factor contributing to the decrease in productivity was the elephant damage which not only occurs at Engelbrecht but also in the whole of the Kunene Region (Kakukuru, 1995).

The healthy mopane forests that occurred in the north-western part of the country are deteriorating with an increase in human population (Marsh, 1990). At Engelbrecht, 278 logs were used to build a house (see Humavindu, this volume). The people themselves confirmed that they now have to travel a longer distance to get straight logs for construction and even fuelwood, illustrating that the numbers of trees have decreased in the area. The percentage of dead materials on trees showed no significant difference between trees near and far from the waterhole (fig. 4).

Many African countries have doubled their population in the last thirty years. More people mean more livestock and more mouths to feed. The same piece of land would have to produce twice the amount of food it presently produces to meet the demand (Middleton, 1991). Increase in demand for food contributes to extensive land use which causes desertification. Degraded land may take years to recover. To rehabilitate the land and obtain a desirable vegetation cover, people should maintain fewer animals (Behnke and Scoones, 1992), especially elephants which are increasing in numbers. Hunting or culling of animals should be considered.

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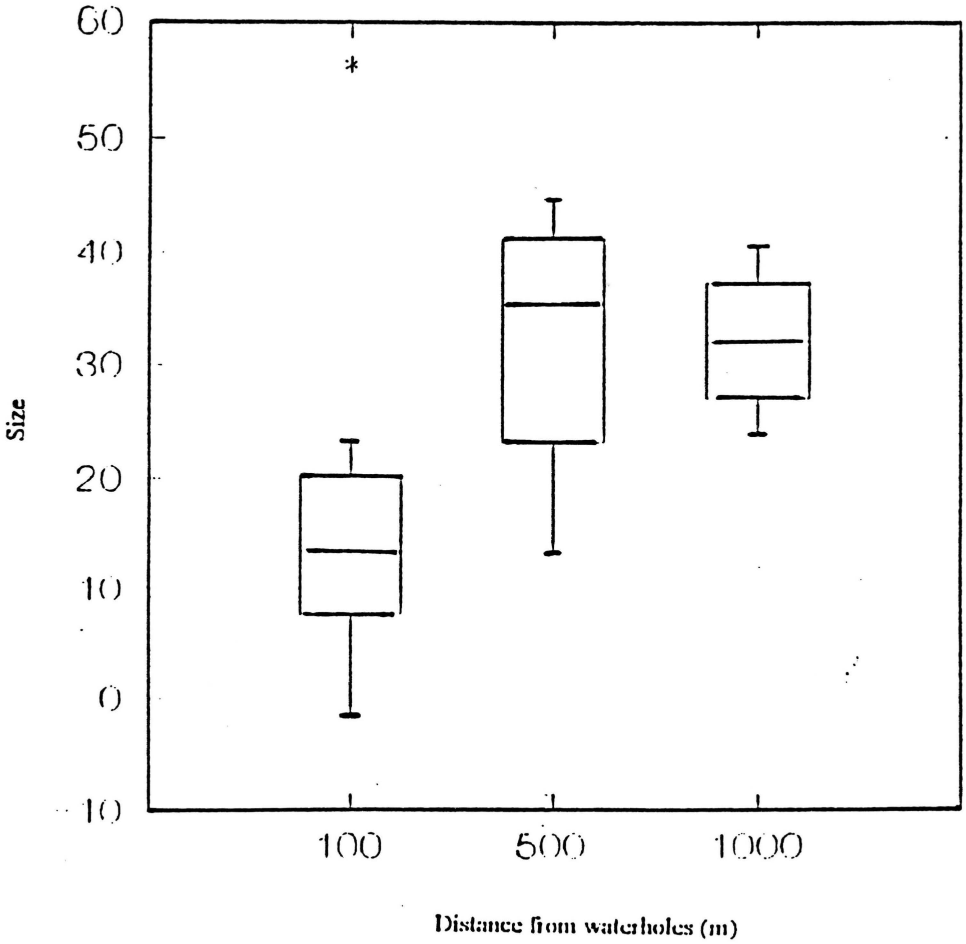
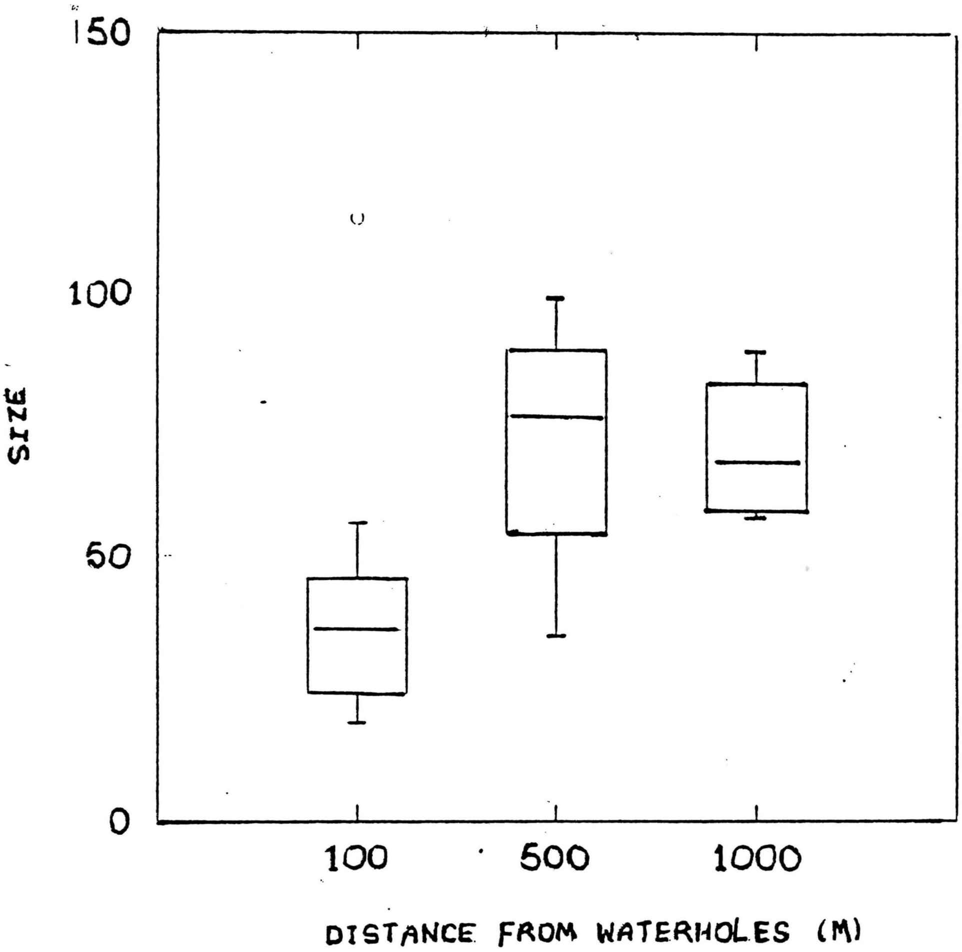
Fig. 1. SIZE DISTRIBUTION OF MOPANE TREES.



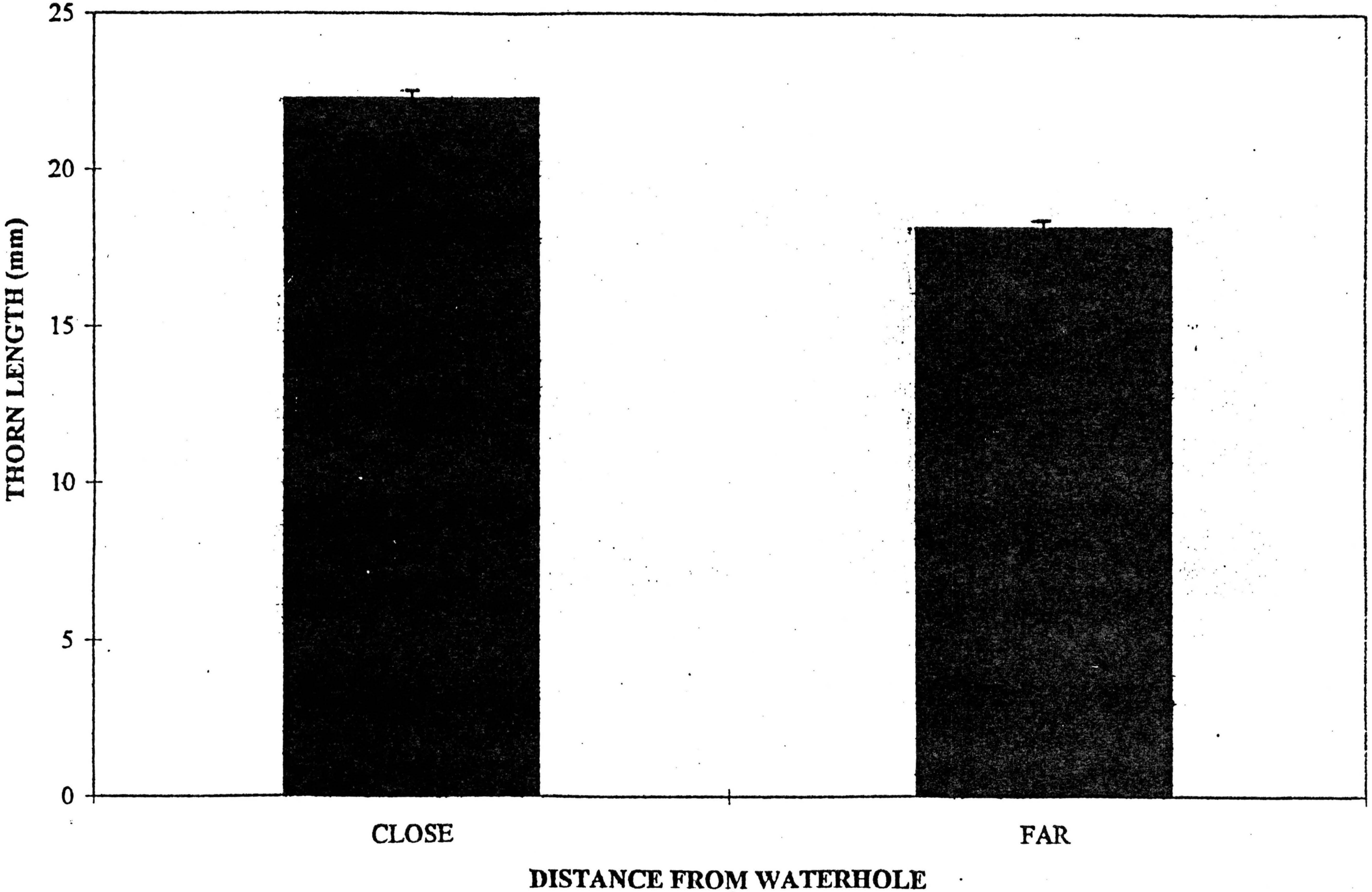
The following weightings of each of the mopane varaibles were obtained for the first principal component: 0.560 x tree height, -0.545 x canopy diameter, 0.084 x side branches, 0.437 x leaf number and 9.625 x leaf size. Using Kruskal-Wallis, P=0.026. The sizes of all tree species increase from 100m to 500m. The difference between 500m and 1000m is not significant.

Fig. 2. Size Distribution of All Species



The weightings of all tree species was done in the following way: 0.893 x height, 0.233 x canopy diameter, 0.858 x leaf number, 0.257 x average number of leaves, 0.633 x leaf size to obtain the overall measurement of tree size. The sizes of all tree species increase from 500m.

FIG. 3. THORN LENGTHS NEAR AND FAR FROM WATER



The thorns on Acacia erioloba close (< 500m) are longer than those on A. erioloba far (1000m) from the waterhole. (SE = mean + or - 1)

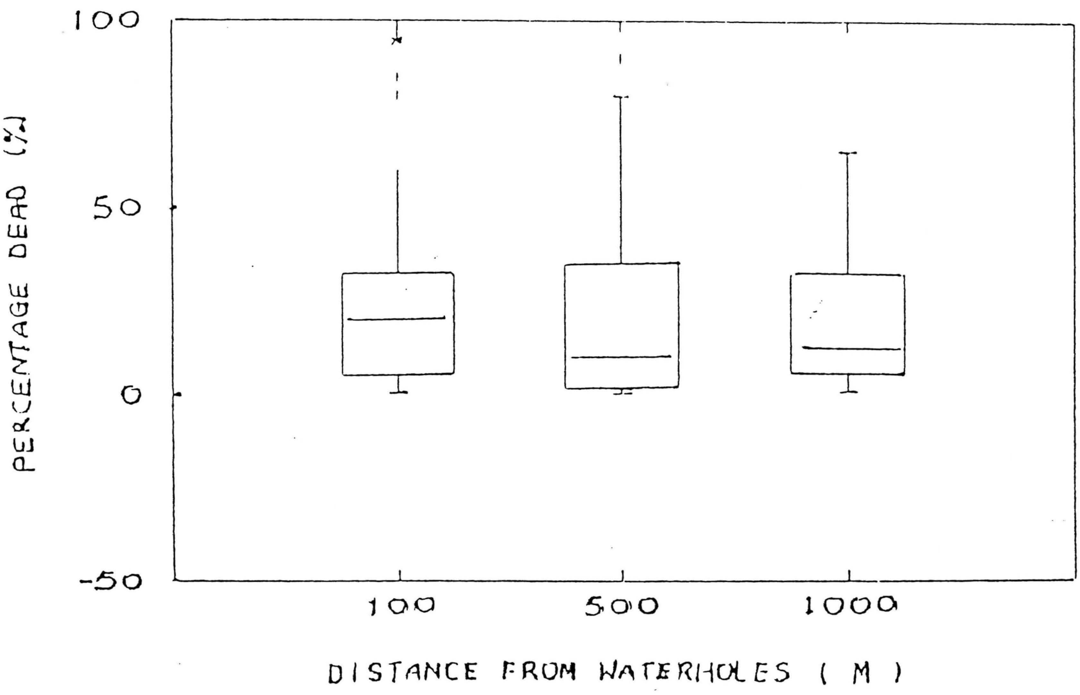
4

ER ANALYSIS OF PLANT COMMUNITTES

= CLOSE TO WATERHOLE 1
= CLOSE TO WATERHOLE 2
: 500m FROM WATERHOLE 1
500m FROM WATERHOLE 2
1000m FROM WATERHOLE 1
1000m FROM WATERHOLE 2

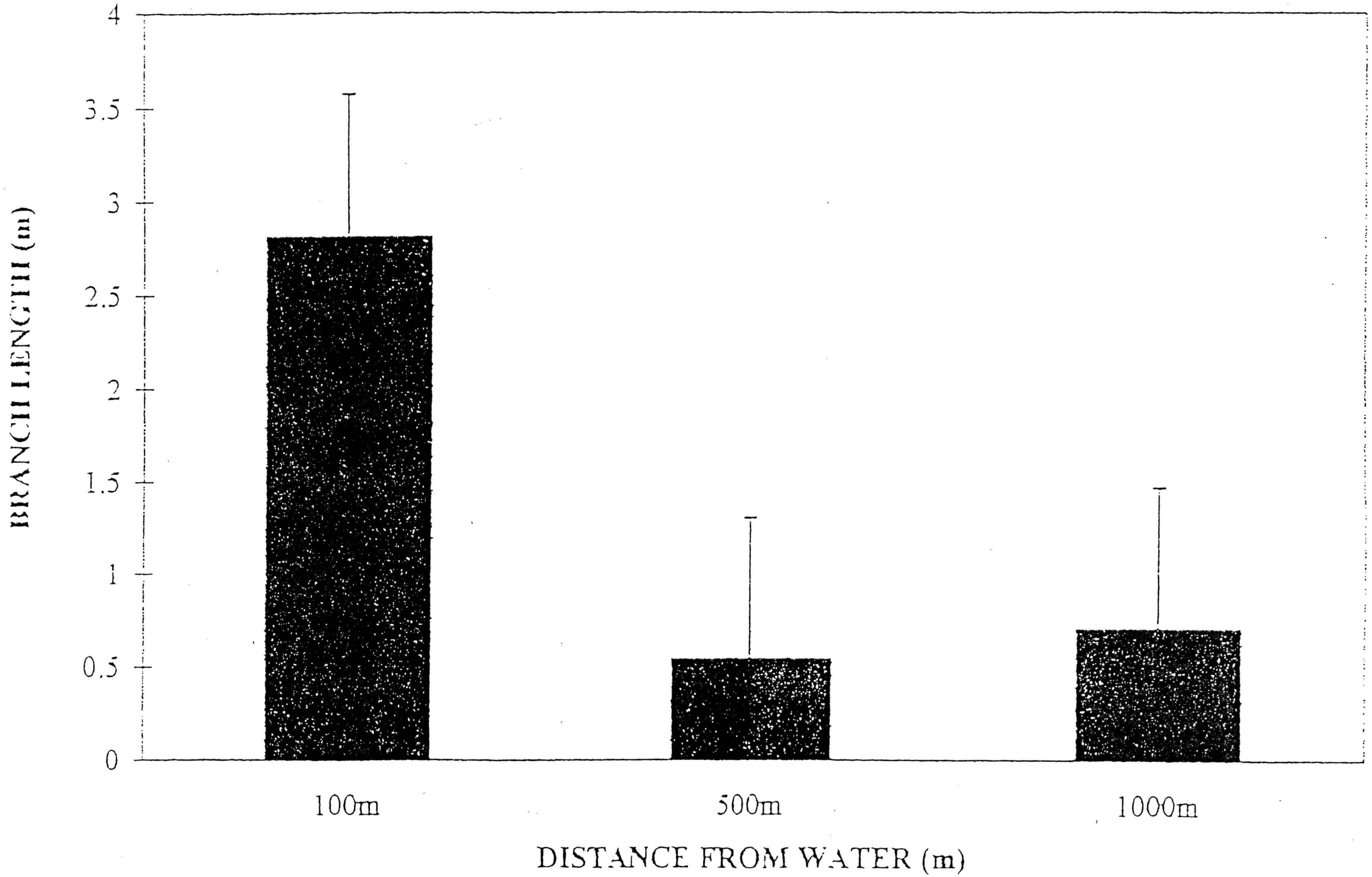
Plant communities at 500 m (W1I)and 1000m (W1F)from waterhole 1 show a higher degree of similarity and these two communities are closely related to communities closer (100 or <) to waterhole 2 (W2C). The next close linkage to W2C are with communities at 500m from waterhole 2 (W2I) which is linked to communities at 1000m from waterhole 2 (W2F). Communities closer to waterhole 1 (W1C) are the most remotely related to others with close linkage to W2F.

Fig. 5 PERCENTAGE OF DEAD TREES



The percentage of dead trees stays constant with distance from two waterholes.

FIG. 6. BRANCH LENGTHS WITH DISTANCE FROM WATER



THE USE OF AN INTEGRATED SYSTEM FOR PLANT DYNAMICS (ISPD) IN NAMIBIAN RANGELANDS

BT Ngairorue

Introduction

The quest for possible techniques to improve rangeland systems requires an understanding of the rangeland dynamics. The ISPD is a newly-developed computer program that can be used as a tool in the study of Namibian rangeland systems. The model archives locally collected data in the form of a data base, assesses the rangeland condition and determines the grazing capacity. An expert mode is constructed by the user and is fed into the program to suggest possible management alternatives for the studied area. Options which are already in existence can be entered into the system to define appropriate management options (Bosch and Booysen 1992).

The system uses ordination techniques to analyze survey data in order to finally construct a degradation gradient. The ordination is used in two ways: the Detrended Correspondence Analyses (DECORANA) and the Degradation Model Construction (DMOC). DECORANA defines a relatively homogeneous grazing area within the data set. Variation occurring within the data set could be explained by habitat information such as structure and soil composition (soil pH, soil depth and the soil conductivity) The first step in the analyses of data is to ordinate all sample plots in order to define possible subsets. The DMOC determines the degradation gradient based on the biophysical data recorded.

The ISPD system is currently being used in rangeland systems in countries such as Australia, New Zealand, Israel and extensively in South Africa. A study in the Namibian rangelands using ISPD was done in the Kunene region.

Materials and methods

This study was carried out on Engelbrecht, a farm situated south west of Kamanjab in the Kunene region. Two study sites were selected (S 19§ 56', E 14§ 73'); a waterhole used by humans and another for elephant use.

The recording of data was done over a range of 50m to 1000m extending from the two waterholes. Three transects of one square meter per site were used to collect soil and grass data. Three data sets were collected at each point and the average then used to account for the data at the point. The total number of each species occurring on the transects was recorded. The average of the total mass of all species per transect gave the total biomass in grams at that specific plot. This value was used to calculate the maximum production rate per plot, ranging from the minimum to the maximum production value. The grass species were identified and coded in letters for ISPD format, (e.g. *KOHA SPP* for *Kohautia.spp* and *STIP* for *Stipogrostis*). See (appendix 1) for the complete table of codes. Soil samples for pH analyses, soil type, soil depth and the soil conductivity are essential to explain the underlying factors surrounding the variations in the habitat of the study area. An expert approach system is utilized to calculate the grazing capacity of the area. A module is constructed with a combination of various inputs and run time questions. The net-biomass available to grazing animals is also calculated. The expert system suggests some management options for the maintenance or improvement of the field condition.

Results and discussion

DECORANA results for both waterholes suggest that the waterhole areas have significantly different habitat characteristics so that the data should be split and treated as two data sets (fig.1). Biomass production increases with distance from the home waterhole but it does not support the split of data into two homogeneous grazing areas (fig.2). Better species (i.e.more palatable) namely the Unknown spp (species heavily utilized which could not be identified) of grasses occur more on the right hand side of the ordination (home waterhole) and are replaced by *Geigeria ornaliva*, *Enneapogon desvauxii* and *Tricholeana manachne* toward the left hand side (the elephant borehole) of the gradient (fig.3). The relatively homogeneous grazing area is not apparent in the data sets and a split of the data set into two cannot be accomplished with a limited sample size and inadequate habitat data.

The degradation gradient of the elephant borehole is towards the borehole (more palatable species occur with distance from the elephant borehole), the presence of better species criteria on the home waterhole seems to favor the occurrence of better species closer to the waterhole although low in biomass (fig.4). Water holding capacity of the soil indicates a range of 70%-80% for the two waterholes (elephant and home waterholes) fig (x) and this shows no significant difference with the x-test ($p<0.05$)

The degradation gradient is supported by the abundance of *Unknown spp* (fig.6), because it increases from the elephant borehole to the home waterhole Its absence on the elephant borehole side is indicative of overgrazing at the borehole side and its abundance toward the home waterhole shows less utilization on that side of the area. The presence of favorable habitat criteria could also attribute to the abundance of *Unkown spp* toward the home waterhole. The abundance of *Geigeria* as depicted in fig.7 and its increase towards the elephant waterhole, indicates again the over-utilization at this end of the gradient while its gradual decrease toward the home waterhole indicates improvement or less utilization with distance away from the waterholes. The Tall grass exhibited a similar pattern to *Geigeria*, with a typical increase away from the home waterhole (fig.8). This species' abundance toward the elephant waterhole indicates over-utilization on that side and again shows less utilization as its decreases away from the waterhole.

The degradation model (fig 4) is rotated 180° (fig 9a) when utilized as a condition assessment tool, with good condition on the left and poor condition on the right. The home waterhole is represented by the left and the elephant borehole by the right in the flipped ordinates. The x-axis was also subdivided into sections as in the study area. The arrow indicates the condition of a site evaluated relative to all the sides used in the construction of the degradation gradient. The condition value of 18.5 is expressed as a percentage and should be compared to the ideal 100%. A veld value of 18.5% is very low compared to the ideal 100% and indicates a very poor veld or a heavily overgrazed area.

For the Gaussian regression fitted in the species abundance values along the first axis (gradient of degradation) for the *Unknown spp*, the goodness of fit is illustrated by supporting statistics at the bottom of the graph showing the standard deviation, root mean square error, the coefficient of determination and the Willmot index for model performance (fig.10). These regression equations for species abundance are used for calculating species composition along the gradient in the population dynamics routine. It also serves to characterize species population dynamics within both a deteriorating field and a recovering field condition. The species may decrease or increase in both field conditions, it is an indication in this case that the *Unknown spp* react like typical decreaser species (fig.10), the gradient is toward the home waterhole. The *Unknown spp* decreases away from the home waterhole. The regression equation fitted in the species abundance for *Trig mon* (fig.11), *Gei orn* (fig.12), *Blep spp* (fig.13), *Tall gra* (fig.14) and *Enne des* (fig.15) indicate that these species are increaser species in the direction of the elephant borehole.

Conclusion

The species response to overgrazing and their successional trends made the ISPD and ideal tool for condition assessment at Engelbrecht. A non-degraded area is characterized by a high abundance of palatable species. (O.J.H Bosch et al 1990).

The abundance of the unpalatable species indicates a degraded or disturbed area. The home waterhole shows a high abundance of palatable grass namely the Unknown grass. This species decreased toward the most degraded area and is thus known as a decreaser species, indicating degradation (Janse van Rensberg 1987). The grazing of palatable species releases the unpalatable grass species from competition (Trollope 1987) as shown by the elephant borehole. Browsing by both elephants and domestic animals in Engelbrecht has an effect on the vegetation. The browsers tend to reduce production near the immediate vicinity of the boreholes. (Ngololo in this volume).

The model suggests a need for the reduction in the number of stock in the Engelbrecht area and this decision needs serious consideration as the field condition could deteriorate if no appropriate measures or alternative remedies are implemented. Following the management options given by the expert model it's advised to follow the recommendations and hence alleviate grazing pressure from the veld. This entails movement of stock to other areas that have received good rains and that are capable of taking up additional stock from this areas. Another alternative could be selling of stock.

Vegetative variations that may occur in Engelbrecht need constant monitoring due to the complexity of the factors that affect system transfer from one state to the other.

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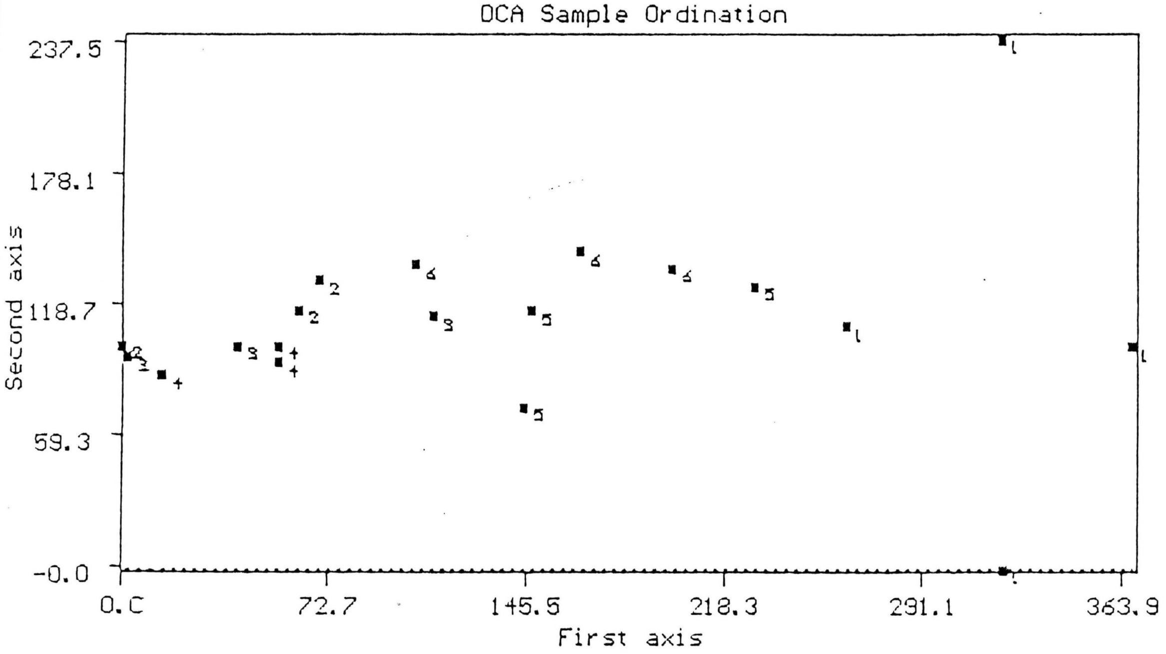
ORDINATION: Habitat = Site descript USED MEM 87 K

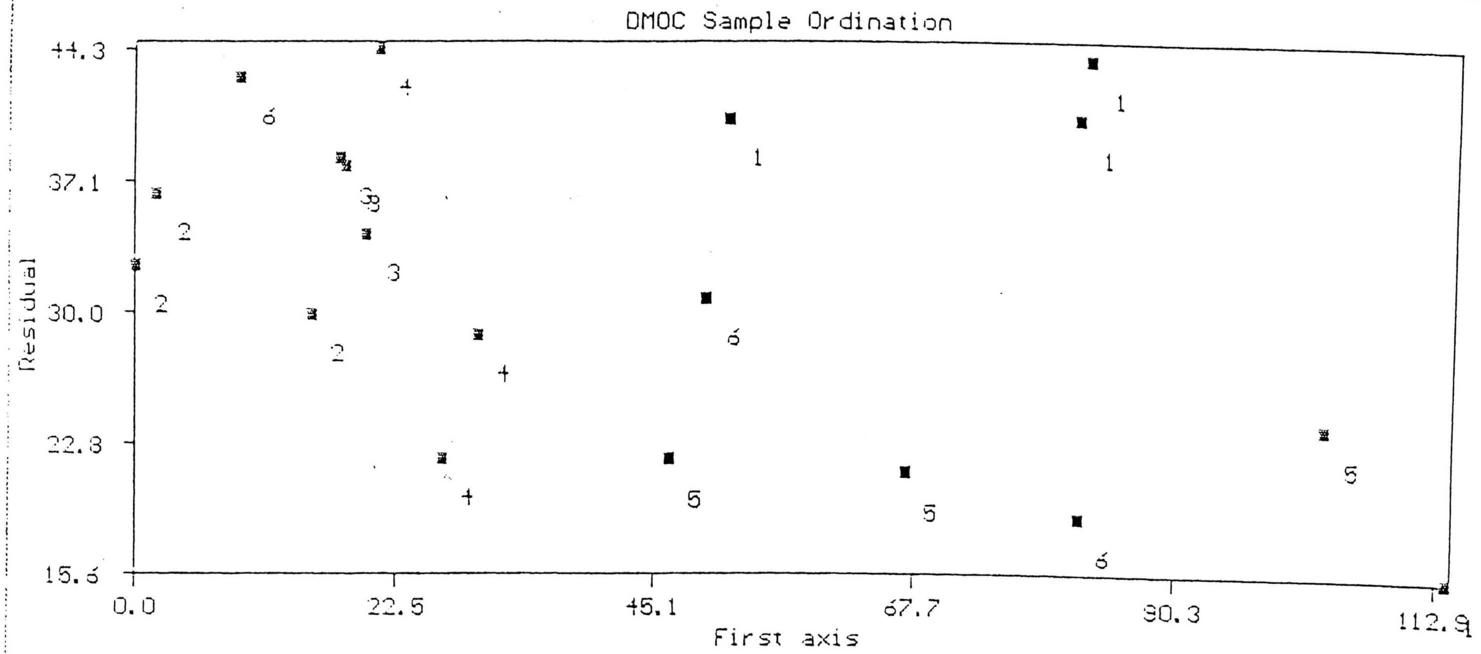


Number of times to RESCALE axis	4
Number of SEGMENTS for detrending	26
Rescaling THRESHOLD	0.0
DOWN WEIGHTING of rare species	NO

Types of Site description

1. Home Borehole
2. Elephant borehole
3. Elephant borehole 500m
4. Elephant borehole 1000m
5. Home Borehole 500m
6. Home Borehole 1000m

ORDINATION: Habitat = Site descript USED MEM 47 K



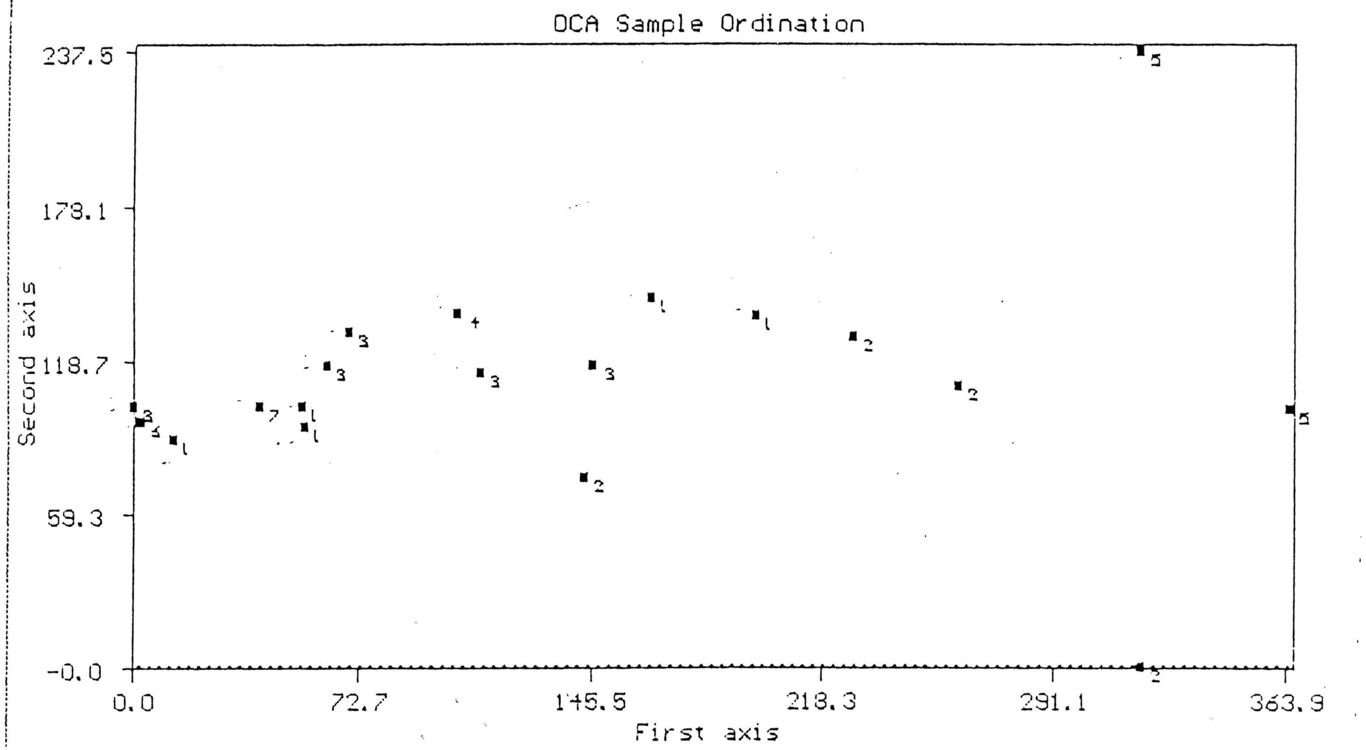
ITERATIONS = 24

RESIDUAL = 7.90276E-10

Types of Site description

1. Home Borehole
2. Elephant borehole
3. Elephant borehole 500m
4. Elephant borehole 1000m
5. Home Borehole 500m
6. Home Borehole 1000m

ORDINATION: Habitat = Max Prod {USED MEM 87 K



Number of times to RESCALE axis	4
Number of SEGMENTS for detrending	26
Rescaling THRESHOLD	0.0
DOWN WEIGHTING of rare species	NO

Types of Max Prod Spp

1. Enne des
2. UNKW GRS
3. TALL GRA
4. GEIG ORG
5. SEED L12
6. TRIG MON

Fig 3: From the Decorana result it is evident that the better species namely, Unknown spp. (Palatable grasses which could not be identified but which was heavily utilised) and Seedling 2 occurs on the right-hand side of the ordination and get replaced by *Geigeria ornaliva*, *Enneapogan desvauxii* and *Tricholaena manachne* towards the left-hand side of the gradient (The x-axis).

4. The DMOC results indicating the degradation model with both waterhole data sets seen as one homogeneous grazing area.

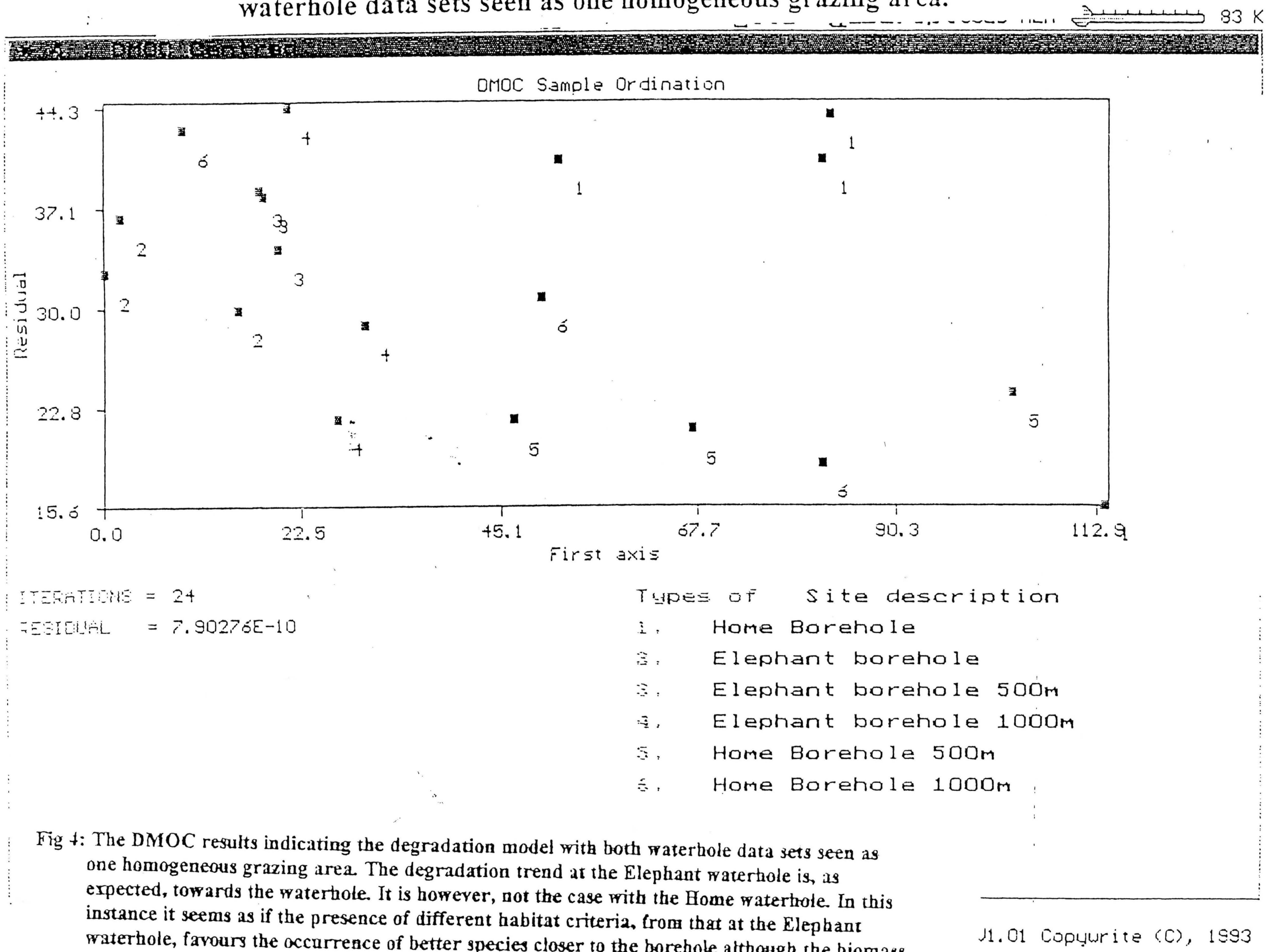


Fig 4: The DMOC results indicating the degradation model with both waterhole data sets seen as one homogeneous grazing area. The degradation trend at the Elephant waterhole is, as expected, towards the waterhole. It is however, not the case with the Home waterhole. In this instance it seems as if the presence of different habitat criteria, from that at the Elephant waterhole, favours the occurrence of better species closer to the borehole although the biomass of these species are very low. Unfortunately this could not be substantiated because of a lack of habitat and specifically soil data.