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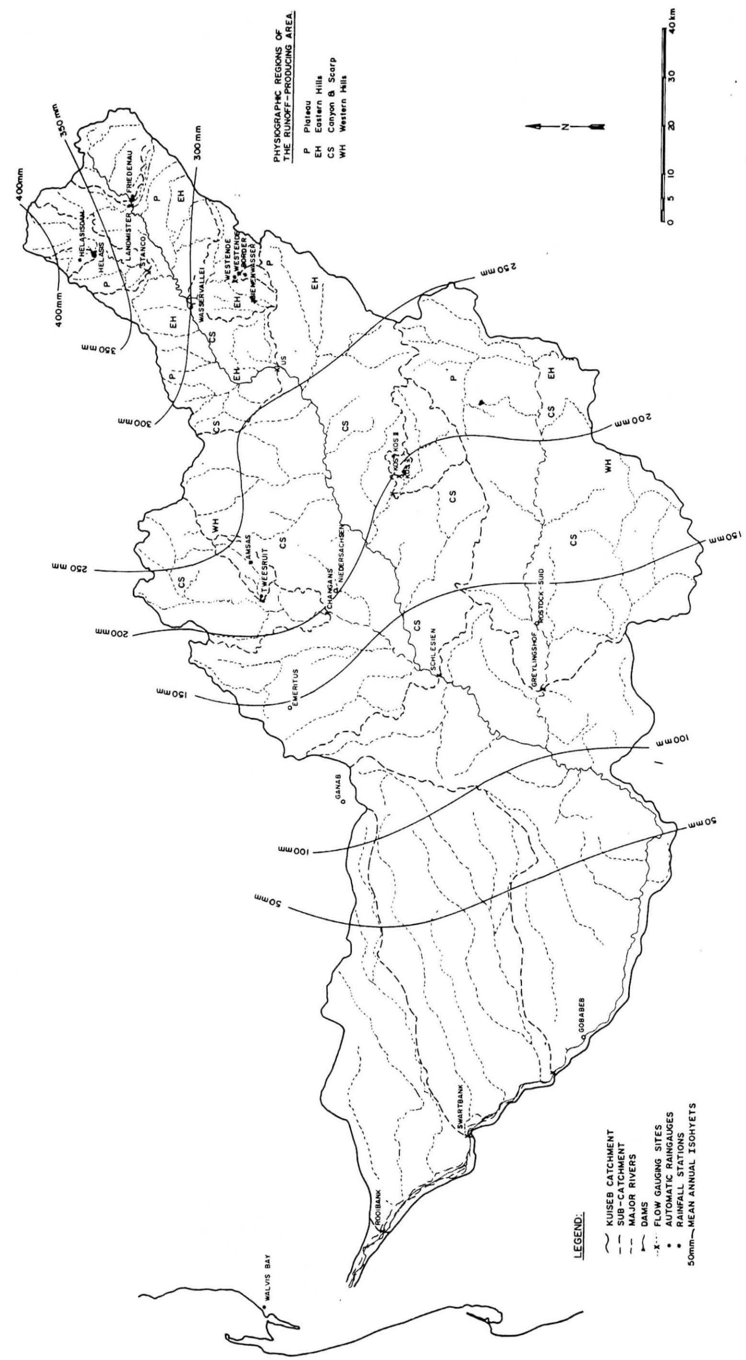

Figure 1. Rainfall and runoff over the catchment area of the Kuiseb River.

4. SURFACE WATER HYDROLOGY OF THE KUISEB

A Hattle, Department of Water Affairs, SWA/Namibia

THE KUISEB BASIN

Catchment size

The total catchment area of the Kuiseb upstream of Rooibank is 14 700 km^2. Of this, only the area upstream of the flow gauging weir of Schlesien (see Figure 1) on the main river, and upstream of the flow gauging station of Greylingshof on the Gaub River should be considered as runoff-producing. These catchments are 6 520 km^2 and 2 490 km^2 in size respectively. The remaining 5 690 km^2 is largely desert plain yielding runoff to the main river only in exceptionally wet years.

Hydrologic zones of the runoff-producing area

Hydrological investigations have been geared to study firstly the flow down the main channel, and secondly the variations in runoff originating from four different geomorphic zones of the Khomas Hochland and Escarpment. These zones and the monitoring points are indicated on Figure 1.

RAINFALL

Gauging network

By October 1982, the Hydrology Division of the Department of Water Affairs, SWA/Namibia had installed eleven automatic rain gauges within the catchment. The positions of these are shown on Figure 1. At all but one of these, six-minute intensities can be determined. One rain gauge was installed in 1973, but the others have only been in operation since dates ranging from October 1977 to April 1981.

In addition data from daily-read gauges are available from the Weather Bureau. This network varies, a few stations having been opened over the past few years, but a number having closed recently.

Average rainfall

Mean annual isohyets based on long-term records up until December 1976 were plotted by Richardson and Midgley and are re-produced for the Kuiseb area

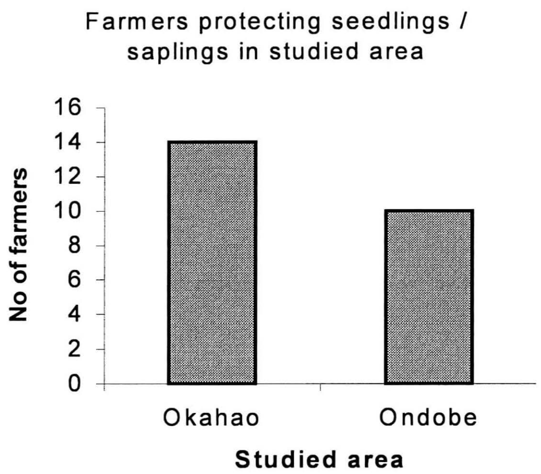

Figure 16 :Illustrating the number of farmers protecting seedlings and saplings Okahao and Ondobe (n= 42).

Comparison of tree protection in the two areas.

Many seedlings emerge annually, but not all of them can grow because some are not protected from browsing by livestock. Twenty-nine out of forty- two interviewed farmers are not doing any direct management activity to protect or encourage seedling/saplings growth. Generally, large proportions of seedlings and saplings in study areas are unprotected. We found that protection usually occurs when farmers want more fruit trees.

Methods of seedlings/saplings management observed in study areas.

- Thorn branch protection: Seedlings germinating in fields are covered with thorn branches to protect them from livestock browsing.
- Applying manure: Manure is applied to seedlings/ saplings to encourage growth; however the practice is not common in the area. Only nine farmers said they apply some manure on their seedlings/saplings.
- Growing trees inside the homestead: This is a common practice in both study areas. Direct and casual seed dispersal is the common method of sowing. Some farmers, especially in Okahao, have transplanted some seedlings from outside the farm to the homestead.
- Pruning: This involves cutting off low branches from sapling to encourage growth. This practice is mostly observed in Ondobe.
- Making wire or wood fence surrounding the saplings: This is mainly done to saplings in the cultivated and uncultivated area within the farm to protect them from livestock

in Figure 1. The long-term average rainfall over the whole of each sub-catchment is summarized in Table 1. Rainfall data for various stations in the catchment are presented in Figure 2.

Table 1. Mean annual rainfall for sub-catchments.

Catchment outlet (Flow gauging site)	Catchment area (km^2)	Long-term rainfall over catchment (mm/a)
Rooibank	14 700	159
Swartbank	13 600	170
Gobabeb	11 700	190
Schlesien	6 520	239
Us	1 900	316
Landmister	231	334
Friedenau	210	335
Greylingshof	2 490	181
Changans	690	230
Tweespruit	81,6	243
Kos Tower	231	212
Kos Weir	20,1	205
Stanco	276	380
Heusis	38,4	394
Wasservallei	266	280
Westende	17,3	275

The mean annual rainfall for the 5 690 km^2 downstream of Schlesien and Greylingshof is only 58 mm. The mean annual rainfall over the runoff-producing area upstream of Schlesien is 239 mm and upstream of Greylingshof is 181 mm. Over these two runoff-producing areas therefore, some 2 000 million cubic metres of rain falls annually on average.

Rainfall during the project

Throughout this report, reference is made to the drought conditions of recent years. Since intensive monitoring began, the rainfall over the catchment dropped to very low levels (Figure 2 and Table 2).

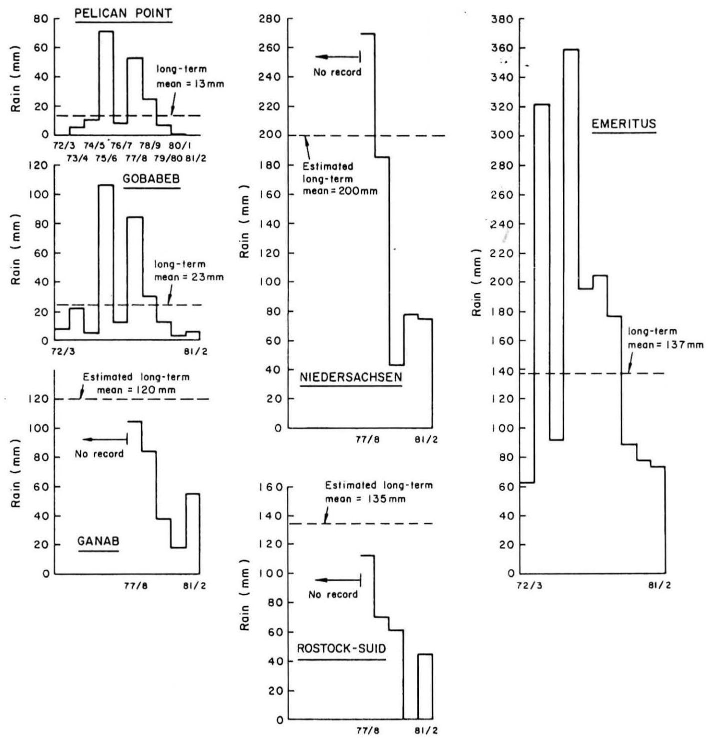

Figure 2. Rainfall data for various stations in the Kuiseb catchment.

Table 2. Seasonal rainfall as percentage of long-term mean.

Site	Mean annual rainfall (mm)	Rainfall as percentage of mean				
		1977/78	1978/79	1979/80	1980/81	1981/82
Heusis	350	141	91	73	41	43
Westende	280	134	113	105	38	44
Tweespruit	220	148	68	73	32	47
Kos I	200	182	100	60	23	34

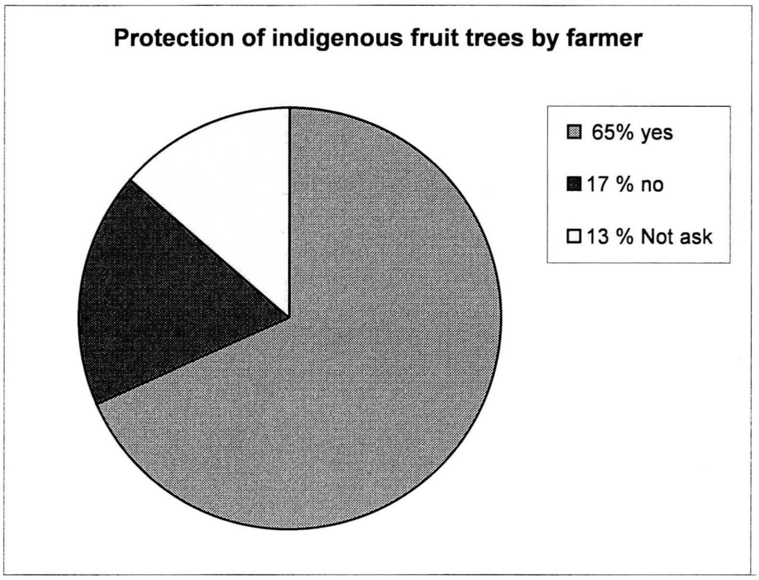

Figure 15: Showing the percentage of farmers (n=23) that protect their fruit trees.

Most people showed interest in protecting their indigenous fruit trees seedlings/saplings. The limiting factor is water and most seedling die or wilt after the rainy season. Some farms have few fruit trees in their fields and they encourage seedlings/saplings growth. In farms with many fruit trees people do not protect seedlings/saplings because they have to secure enough space for crop production. If the seedlings are not protected, livestock will most likely destroy them through browsing.

Ondobe

We observed that farmers in Ondobe are not heavily involved with seedlings/saplings protection. Many fruit trees have grown on the cultivated field and some of them were protected in the homestead until they became mature enough to cope with the browsing pressure. All the directly protected seedlings and saplings were found either on the cultivated field or in the homestead. This may be because farmers in Ondobe do not have livestock browsing their fruit trees as frequently as farmers in Okahao since livestock in Ondobe usually remain at distant cattle posts.

Some farmers are selling Marula nuts and Ombike (liquor made from fermented fruit like Jackal Berry, Ziziphus and Bird Plum fruit) at informal markets. We found that the farmers selling these products were managing seedling/saplings more than those who were not selling any fruit products.

It should be pertinently noted that runoff during the "wet" 1977/78 season was also low, presumably on account of the good vegetative cover which had built up over the previous few good rainfall years.

SURFACE FLOW

Total runoff from the upper catchment

The surface water input to the Lower Kuiseb system is the river flow in the Kuiseb passing Schlesien, and the river flow of the Gaub passing Greylingshof.

Kuiseb River

Gauging began at Schlesien in 1960/61 and the gauging efficiency of the weir under heavy sedimentation has only recently been closely examined by an hydraulics engineer. Preliminary results indicate that the mean annual runoff at the site is in the vicinity of 20 million cubic metres. The mean, of course, is influenced by rare very high flows, and the median annual flow is about half the mean (10 million cubic metres). The coefficient of variation of the annual flows is high, with a maximum of 106 million cubic metres and a minimum of 0,007 million cubic metres over the 21 years of satisfactory record.

The last season in which flow reached the Salt Flats was 1973/74, during which the flow past Schlesien was 60 million cubic metres. The last recorded flow into the sea was in 1962/63 when the Schlesien flow was approximately 106 million cubic metres. Indications are that the flow during 1933/34 could have been twice this amount.

Gaub River

Flow measurements at Greylingshof have not yet been critically examined, but indications are that the flow contribution from the Gaub River would be of the order of 20 percent of that of the Kuiseb.

Dissipation of flow downstream

The development of a model to predict the extent of recharge in the Lower Kuiseb, given the input at Schlesien and from the Gaub is currently receiving attention. There have been insufficient carefully monitored flows to calibrate the model as yet. This is an on-going long-term study.

Some information on flow dissipation is provided in Table 3.

Sediment yield

Monitoring has begun to determine the sediment carried in the Kuiseb to establish

- the long-term inflow of sediment to the Lower Kuiseb and

Table 3. Downstream limit of flows in the Lower Kuiseb.

Season	Flow ($10^6 m^3$) at Schlesien	Flow ($10^6 m^3$) at Greylingshof	Farthest point reached by flow downstream
1962/63	106	?	Sea
1973/74	60	?	Salt marsh
1975/76	37	?	Salt marsh
1977/78	7	minimal	Well point 01*
1978/79	4	minimal	Well point 01*
1979/80	0,2	0,5	Well point 16*
1980/81	1,6	minimal	Well point 06*
1981/82	0,1	1,3	Well point 12*

* Estimated from Division Geohydrology gaugings

- the relationship between sediment yield and vegetation cover over the catchment.

There have been too few runoff events and therefore too little data to evaluate at this stage.

Effect of vegetation cover on runoff

Three vegetation cover surveys have been made in the runoff-producing portion of the Kuiseb catchment. The first two were in June 1979 and September 1980 and were done using a wheelpoint apparatus and chain. Each survey covered approximately 7 km in each of the four physiographic regions gauged for runoff.

Taken for the area as a whole, the 1980 survey reflects a 27 percent reduction in basal area coverage compared to the 1979 survey.

No survey could be done in 1981, and the results of the September 1982 survey are still awaited. For this last survey, a subjective veld condition assessment technique similar to that described by Roberts and Fourie (1975) was used.

Although many years of monitoring will be required, it is expected that a reduced vegetation cover will greatly increase the sediment flow to the Lower Kuiseb. Experience throughout South West Africa/Namibia indicates that increased vegetation cover significantly reduces runoff, but this remains to be quantified.

SUMMARY

Information regarding flow in the Lower Kuiseb is scarce. There is some knowledge of the flow entering the area but the Gaub River contribution must be analysed further. The past few seasons of drought have produced so little runoff that little analysis has been possible on aspects such as flow dissipation, sediment yield and rainfall-runoff relationships.

	Ondobe			Okahao		
Species	**Juveniles**	**Saplings**	**Trees**	**Juveniles**	**Saplings**	**Trees**
Berchemia	8	13	158	4	4	45
Diospyros	40	120	189	0	0	2
Hyphaenea	101	108	100	147	155	317
Sclerocarya	21	36	269	11	80	206
Ziziphus	0	29	46	0	8	8
Total	**170**	**306**	**762**	**162**	**247**	**578**

Table 10: The number of juveniles, saplings and mature trees on farms in Ondobe and Okahao Constituencies.

3.6 Management of seedlings and saplings

Seedlings are defined as plants that are less than 0.3 meters tall and saplings are seedlings that are taller than 0.3 m but less than 1.5 m in height. Generally, farmers in both study areas are known to be doing little on direct management of seedlings and saplings. In north central indigenous fruits are used in various ways for traditional practices. Most protected seedlings and saplings in our study areas were Bird Plum and Marula, as these trees play any important role in nutrition of rural people.

Okahao

Most farms visited have indigenous fruit trees except those farms that have only recently been settled. We found out that new settlers are trying to plant some fruit trees in their fields. In the Oshilongo areas (areas that have been settled for many years and thus have more developed infrastructure, such as roads, schools, piped water and shops), small Palms known as “Oshivale” in Oshikwanyama are found all over in the fields. People in Oshilongo are afraid that palms will become too abundant and compete with their crops, thus farmers are not protecting them.

RECOMMENDATIONS

Monitoring of runoff in the Khomas Hochland, at Schlesien and Greylingshof and in the Lower Kuiseb must be continued. As soon as there have been a few sizeable floods downstream of Schlesien and Greylingshof, the flood dissipation model must be critically tested and refined if possible. The monitoring of flows for silt content must continue, as must the surveys of vegetation cover on the Khomas Hochland.

It is unlikely that a better analysis of the surface water hydrology can be made within two or three years.

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5. GEOHYDROLOGY OF THE KUISEB RIVER

L W R Blom and P M Bouwer, Department of Water Affairs, SWA/Namibia

HISTORICAL REVIEW WITH EMPHASIS ON THE INVESTIGATION OF THE WATER POTENTIAL OF THE LOWER KUISEB

At present groundwater is abstracted from the dry bed of the Kuiseb River to supply Walvis Bay, Swakopmund, Rössing Mine and Arandis. The main areas of abstraction are A Area (Figure 1) which encompasses the section of the river upstream of Rooibank for a distance of 10 kilometres as far as the Fehlmann well, and B Area which lies approximately 13 kilometres west of Rooibank. Water from both areas is used exclusively by Walvis Bay. Water abstracted from the Swartbank area which extends from Fehlmann well upstream for a distance of 11 kilometres, is pumped to Swakopmund, Rössing Mine and Arandis.

Interest in this part of South West Africa as a source of fresh water is of long standing. It began with the Portuguese explorers, followed by that of the East India Company and the whalers. The latter were familiar with the Hottentot watering post near Walvis Bay.

It was not until the end of World War I that investigations were carried out to establish an adequate water scheme. Increased activity at the outbreak of World War II brought about new activity near Rooibank which led to the development of the A Area.

The long known presence of fresh water at Sandvis and the speculation that this might be due to under-dune Kuiseb channels initiated a programme of seismic surveys (1967, 1970), magnetic traverses (1963, 1973) and gravity surveys (1973). A large part of the investigations was carried out by the National Physical Research Laboratory of the Council for Scientific and Industrial Research under the leadership of J S V van Zijl. Results of the investigations which were on a regional scale showed broad shallow erosional depressions often more than 10 km wide. The presence of channels could only be determined by drilling in the vicinity of the Kuiseb River. Because of a lack of drilling results the course of these channels under the dunes has not been determined. The investigations resulted in the development of the Swartbank area in 1970 to meet the growing water demand. Abstraction rose annually until the requirements of Rössing Mine were supplemented by the development of the Omaruru River Delta source north of Swakopmund in 1979.

destroy the rest during browsing. Many Oshivales (palm shrubs) seem not to grow into Palm trees, because livestock browse on them when they are young.

Another factor may be that women collect leaves from young palms for baskets making. This actually damages the young palm trees and may prevent them from becoming mature trees.

For Marula, browsing by livestock is a major impediment to establishment and recruitment. Goats and donkeys, as well as cattle in Okahao, often browse on saplings and browse the lower branches of mature trees, possibly hindering their productivity.

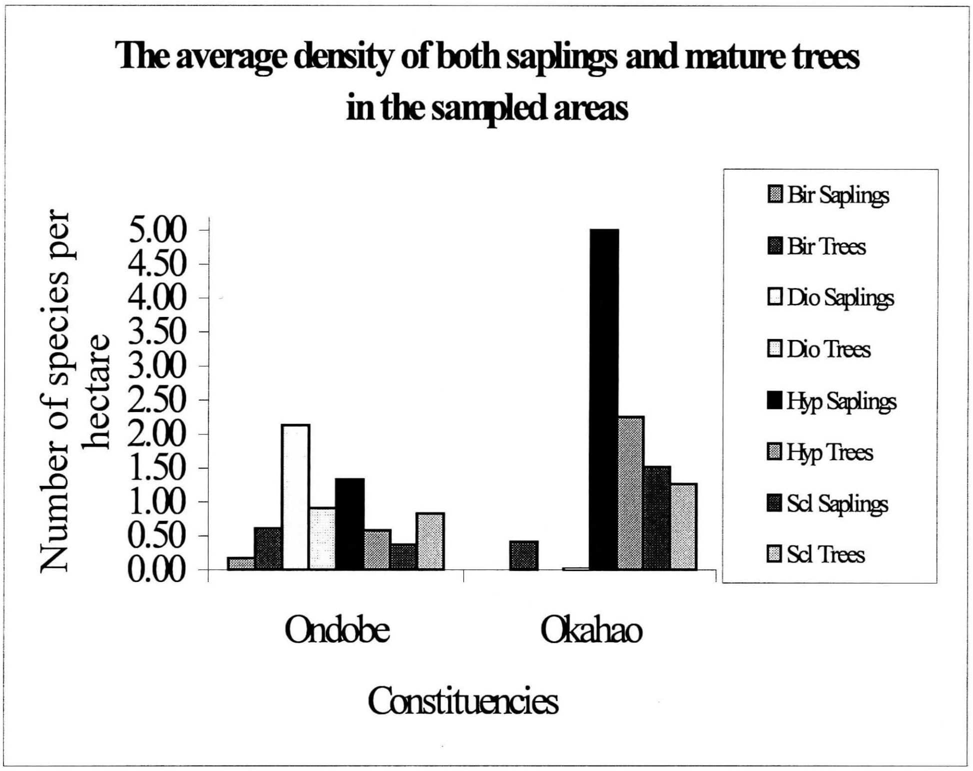

Figure 14: The average density of species on farms studied in both areas.
Keys: Bir= *Berchemia*, Dio= *Diospyros*, Hyp= *Hyphaene* and Scl= *Sclerocarya*.