Agriculture and related issues in the Kuiseb River Basin

By:

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Many facts mentioned in the text are not based on secondary sources but on personal knowledge gained over 22 years of practical field work as agricultural extension technician in the Khomas Region and especially the Kuiseb catchment area by Frank Wittneben.

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A. Baseline information and gaps analysis

The following section is mainly based on Botes et al. (2002), Manning et al. (2002), Manning et al. (2004), Manning and Pallett (2004), Roberts (in prep) and expert inputs from F. Wittneben and P. Klintenberg. The Kuiseb River Basin shows great variation in the distribution of natural features as geology, geomorphology, and geography. Climatic features vary both in space and time within the basin, contributing to an already varied distribution of vegetation and fauna. The Basin encompasses an area of +/-21,940 km^2 (2.194 million hectare).

The basin is divided into three catchment areas (Figure 1):
1) Upper catchment 9620 km^2
2) Middle catchment 11250 km^2
3) Lower catchment 1070 km^2

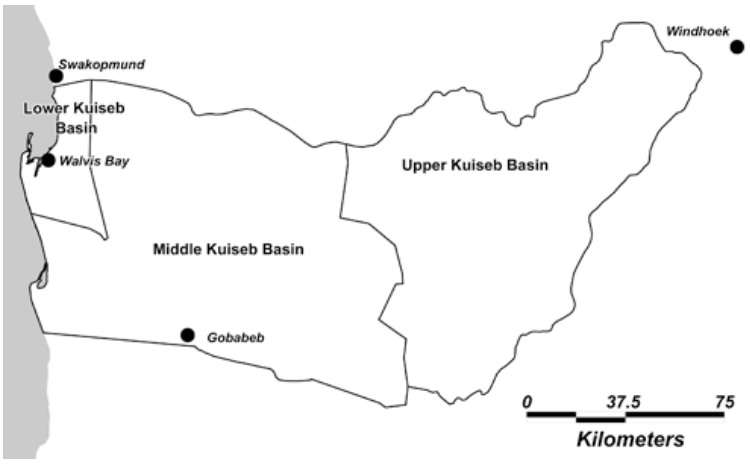

Figure 1. The upper, middle and lower catchments of the Kuiseb River Basin.

1.1 Topography

The topography in the Kuiseb Basin varies from extremely steep mountainous areas in the upper catchment to completely flat gravel plains and undulating dunes in the lower catchment areas (Figure 2). The topsoil in the upper catchment area is very shallow due to pronounced water erosion, which also determines the type of plants growing there. Because of the thin soil cover and the steep topography rainwater has little chance to infiltrate. Where vegetation cover is low and slopes are steep the run off is generally very fast. The result is that very little rainwater will reach the groundwater table compared to flatter and sandier areas elsewhere in the country. As a result surface water is almost non-existing except for single pools of water in very steep and shady canyons and a few fountains.

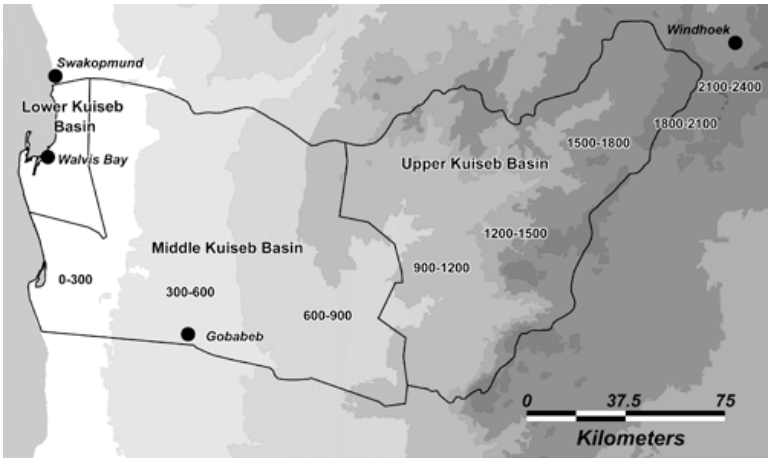

Figure 2. Topography of the Kuiseb River Basin

The rugged terrain of the upper catchment results in clear differences in distribution of plants. An example of this is the distribution of Acacia erubescens (withaak), which predominantly occurs at an altitude of 1500 m.a.s.l. and below. The Acacia reficiens (rooihaak), on the other hand is most common at an altitude of 1400 m.a.s.l. and above. Differing climatic and soil requirements for these two plants most likely cause these differences in distribution. At higher altitudes the annual average temperature is lower and fluctuations more extreme. On the other hand, soil depth also tends to be lower at higher altitudes. Observations have shown that bush encroachment is less of a problem on farms located at high altitudes in the Kuiseb River Basin. This is due to the extremely cold conditions during the winter, which controls the encroachment of bush.

1.2 Geology

The rocks in the basin are dominated by schists and sandstones. In the middle and lower catchment granites occur together with schist's and dolomite, sand and calcrete (Schneider, 2004) (Figure 3). An interesting observation is that, due to the high copper content in the rocks in some parts of the upper catchment, lightings are very common there during rain storms. This leads to an increased risk of veld fires. Something that is evident in the number of veld fires recorded in this part of Namibia compared to the numbers recorded in other parts of the country. Another effect of the high mineral content in the rocks and the soils of the upper parts of the Kuiseb River basin is that the grasses have a high mineral content, making them comparatively nutritious.

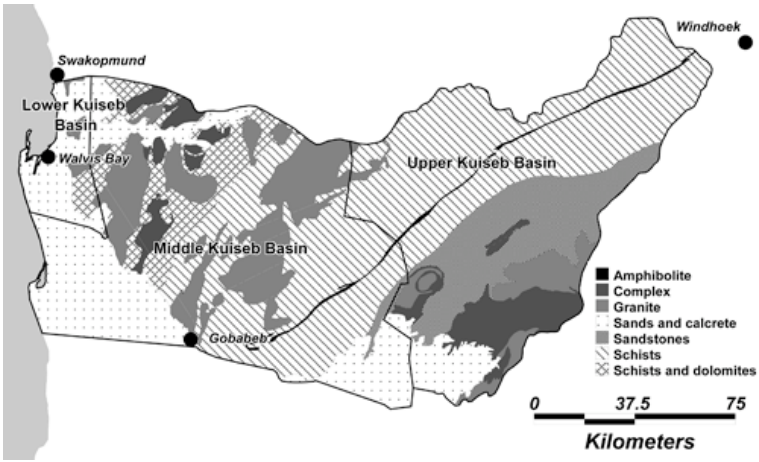

Figure 3. Geology of the Kuiseb River Basin.

1.3 The Kuiseb River

The Kuiseb River is an ephemeral river that follows a path originating in the Khomas Hochland mountain range, flowing through the Namib desert. The river originates approximately 30 km west of Windhoek at an altitude of 2081 m.a.s.l. and reaches sea-level at Walvis Bay (Jacobson et al., 1995). The river course is approximately 420 km long (Figure 4). The river is only flowing for a short period following rainfall within the Kuiseb Basin. The length and intensity of the flow mainly depend on the amount of rainfall received in the catchment area. For most of the year the river therefore has no surface water. It is important to note that the river might not flow every year, nor flow throughout the entire length of the river. Even though the Kuiseb River is an ephemeral river, water is captured, moved and stored in many different ways in and around the main river path, which contribute to the presence and subsequent support of vegetation, wildlife and domestic animals, people and their livelihoods as well as industry throughout the Kuiseb River Basin.

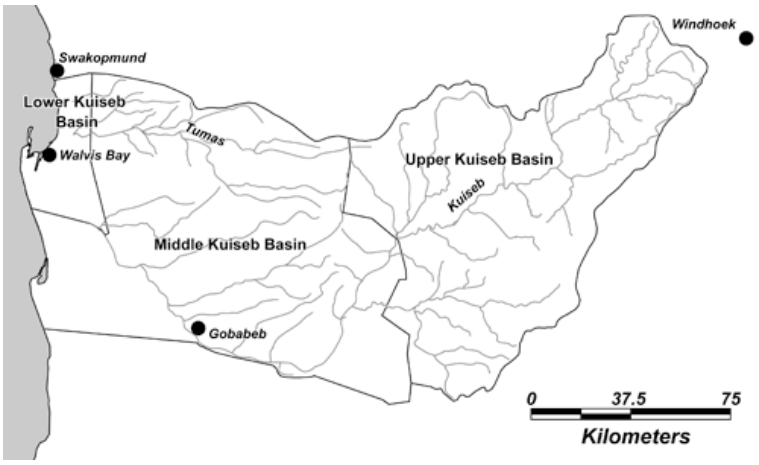

Figure 4. Main river channels and tributaries of the Kuiseb River.

Photo 1. First bridge in the upper reaches of the Kuiseb River, close to Windhoek

The upper reaches of the Kuiseb River is shown in Photo 1. Note the small culverts under the road, to be compared to the size of river crossings further down into the basin. This is a good measure of the amounts of water that is transported by the river. The amount of run off is determined by the steepness of slopes, area of sub-basins feeding a specific tributary, soil depth, soil type and vegetation cover. In general run-off is high in the upper reaches of the basin as the soils are shallow, slopes are steep and the ground cover is sparse, at least during the onset of the rainfall season. Another factor that is of importance is the intensity of rainfall. Rainfall records show that rainfalls in the upper parts of the basin commonly are intense, also contributing to limited infiltration and increased runoff.

1.4 Climate

The climate of the Kuiseb River Basin is determined largely by its geographic position. Lying on the west coast of southern Africa, the climate of Namibia is influenced by three climate systems: 1) the dry, high-pressure anticyclones which drive the Benguela Current along the coastline, 2) the rain-bearing Inter Tropical Convergence Zone (ITCZ) that brings moisture from the Indian Ocean to Namibia in summer, and 3) the low-pressure system of cold-fronts that occasionally brings winter rainfall to southern Namibia. Straddling the Tropic of Capricorn, the effects of these systems are clearly manifested in the Kuiseb River Basin.

In summer, the systems move southwards, placing the ITCZ sufficiently far south to bring rain to Namibia, as the subtropical anticyclones are less effective at blocking it. In winter, the systems move northwards and the dry subtropical anticyclones dominate over southern Africa preventing

moist air from moving into Namibia. However, cold fronts can sweep across the Atlantic Ocean, occasionally bringing rain behind them to southern Namibia.

The anticyclone drives the Benguela Current northwards along our coast from the cold southern Atlantic Ocean. This system has a strong influence on the climate, particularly in the western part of the Kuiseb River Basin, where it causes the extremely arid conditions prevailing there. The cold waters cool the air above the sea to such a degree that it prevents rain-bearing clouds from developing. Rainfall in the basin is largely dependent on moisture bearing clouds, originating thousands of kilometres eastwards over the Indian Ocean. However, these clouds have lost most of their moisture by the time they reach Namibia. Consequently, low rainfall in the eastern reaches of the Kuiseb River Basin, decreases to virtually nothing further west. Together with low humidity, intense radiation and high temperatures, this lack of rainfall creates the arid conditions that characterise the area.

In spite of the generally drying influence of the Atlantic Ocean along Namibia's coast, it does provide moisture in the form of fog. The precipitation from fog can be significant and, although not easily accessible to people, provides a regular source of water to many plants and animals living in the desert. The fog is reaching as far as about 100 km inland from the coast (see separate section below).

1.5 Rainfall in the Kuiseb River Basin

The Kuiseb River Basin is characterised by low rainfall coupled with high evaporation rates. As was stated above, most of Namibia's rain falls in summer from moisture-bearing clouds blown in from the north-east as the ITCZ moves southwards. As the clouds move further and further south and west, they carry less moisture and rainfall decreases. As a result rainfall in the Kuiseb River Basin follows a distinct east-west gradient. Rainfall is highest in the eastern area, where over 300 mm can be expected per year, dropping drastically at the edge of the escarpment, and decreasing to almost nothing in the most western parts. Because so little rain falls in the west, the flow of the Kuiseb River there is almost totally dependent on the amount of rain falling in the eastern parts of the Basin. The average annual rainfall is 350 mm in the upper catchment to less than 50 mm in the lower catchment (Figure 5). In the eastern part of the Basin, above the escarpment, rainfall is seasonal albeit in variable amounts, whereas the west which lies in the central Namib Desert receives very little rain.

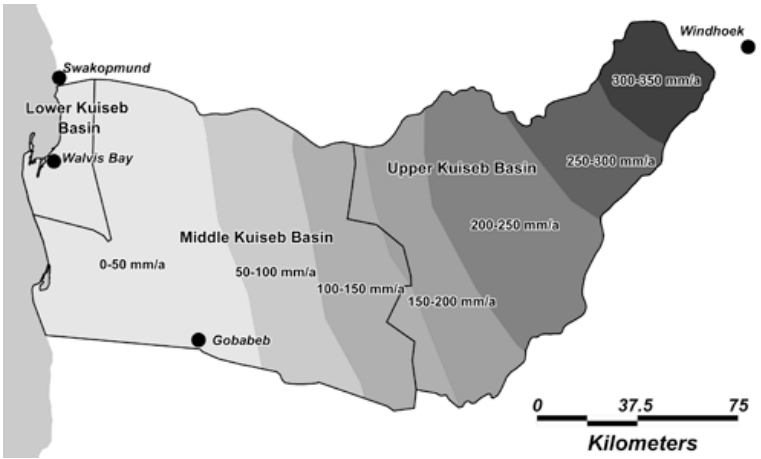

Figure 5. Average annual rainfall in the Kuiseb River Basin.

Rainfall in the Kuiseb River Basin does not only vary geographically, but also varies from year to year. Some seasons receive only a fraction of the rain that falls in other seasons - for example, in 1981/82 Windhoek received only 20 % of the rain that fell in 1999/2000 (Figure 6). It is only in season with relatively high rainfall that the Kuiseb River can be expected to flow all the way to its lower reaches and recharge the aquifers in this area.

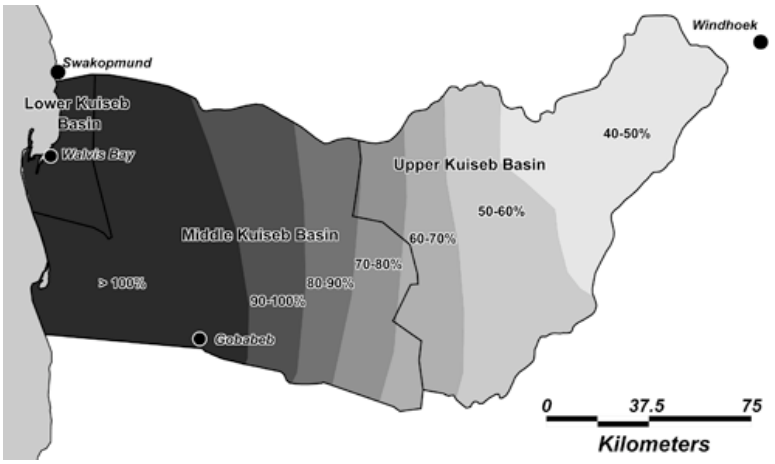

Figure 6. Rainfall variability in the Kuiseb River Basin.

Rainfall commonly also varies substantially within short distances. Topography is one factor that influences this, e.g. mountain peaks as the Gamsberg and koppies (inselbergs) found on the plains west of the escarpment cause updrafts, forcing clouds upwards, leading to condensation and rain on the windward side, and a rain shadow on the opposite side of the mountain.

Apart from the variation from season to season, long-term records of rainfall also show periods of higher rainfall being followed by periods of lower rainfall, as depicted by the five-year running mean for Windhoek and Claratal (Figure 7). These periods of wetter or drier conditions are about 15 years long.

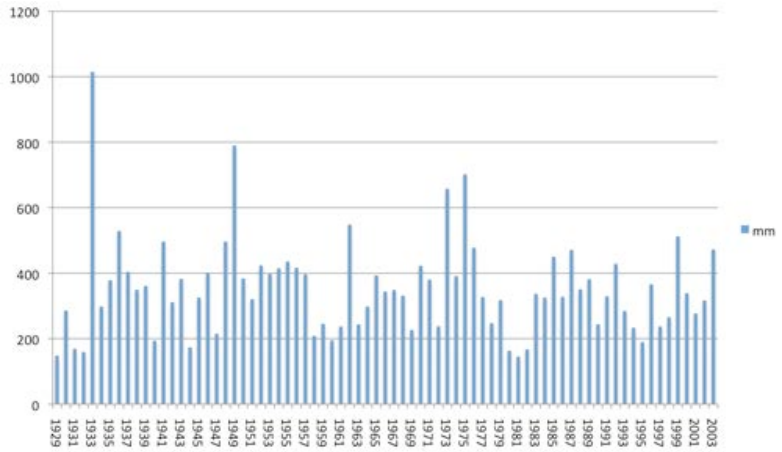

Figure 7. Rainfall recorded at Claratal since 1929/30.

Although rain in the Kuiseb River Basin might fall from as early as September, rainfall mostly occurs between January and April throughout the Basin. Precipitation can occur during the winter as well following occasional massive cold fronts. Although these rainfall events contribute very little to the rainfall in the eastern parts of the Basin, these events can be significant in the areas further to the west. This is illustrated by Pelican Point where these winter rains contribute almost a quarter of the total rainfall received over the past 40 years. Snow was reported at Claratal in July 1982 and June 1994.

The rainfall pattern is often described as having a small peak in early summer, followed by a second, larger peak bringing the main rains later in the season. This can be seen in the records from Claratal 1999/2000 and 2003/2004. These patterns vary between years, e.g. some years most rainfall falls in the early part of the rainfall season, other years the rains come late, towards the end of the rainfall season, or is spread more evenly throughout the rain season. The amount and intensity of rainfall determines both amount of run off and veld condition. Early rainfall triggers germination, and has to be followed by more rainfall, to enable grass and seedlings to establish.

On the other hand, rain falling in March does not leave enough time for regeneration of vegetation before the winter starts. In some years the rainfall is very low, or experience extended periods with less than average rainfall. These periods are referred to as droughts. Droughts can be devastating to both water supply and agriculture. The high variability of rainfall in the Kuiseb River Basin can lead to other kinds of droughts as well.

A form of drought referred to as grazing drought can occur in the Kuiseb River Basin. This drought occurs when the rainfall is too little or too late for grasses to grow. In the Kuiseb River Basin the natural system and land uses are relatively robust and adapted to these conditions. These drought years do therefore not necessarily pose a serious problem to the farmers or the environment, especially when they occur in isolation. However, a few seasons of unfavourable conditions can have devastating effects on agriculture, especially if coupled with other stresses such as overgrazing. If there is no runoff for a number of years, the alluvial aquifers in the Kuiseb River Basin are not recharged and water levels drop, putting pressure on both the woody vegetation along the river and the animals depending on this system.

1.6 Fog

In the western reaches of the Kuiseb River Basin fog brings moisture to an area that otherwise receives little to no precipitation. The fog is an essential source of water for lichens, plants and animals living there. The fog also cools the air, increases air humidity and reduces solar radiation, which contributes to a lower rate of evaporation where it occurs. At the coast fog most often occurs between March and September, while inland fog occurs between August and December. Records from Gobabeb show that fog precipitation is less variable than rainfall in the areas reached by the fog (Figure 8).

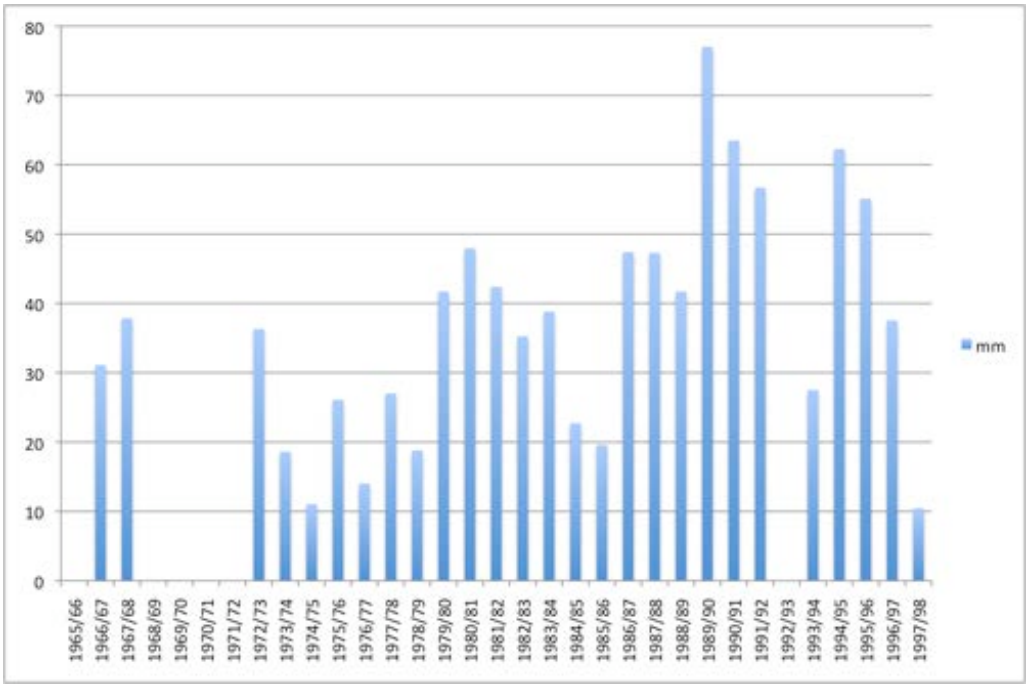

Figure 8. Fog recorded at Gobabeb.

1.7 Temperature

Due to different climate conditions and their influences across the east-west gradient, temperatures show very different characteristics and trends too. Generally the hottest temperatures are measured in the central Namib Desert. Cooler temperatures occur further inland, to the east, especially on top of the great escarpment. Coolest temperatures are experienced along the coast (Figure 9). Windhoek, being at fairly high altitude, experiences high summer temperatures from November to January, but seldom reaching over 30°C. Winter time the

temperature can drop to 0°C and below. The clear skies lead to a wide daily range of temperatures throughout the year.

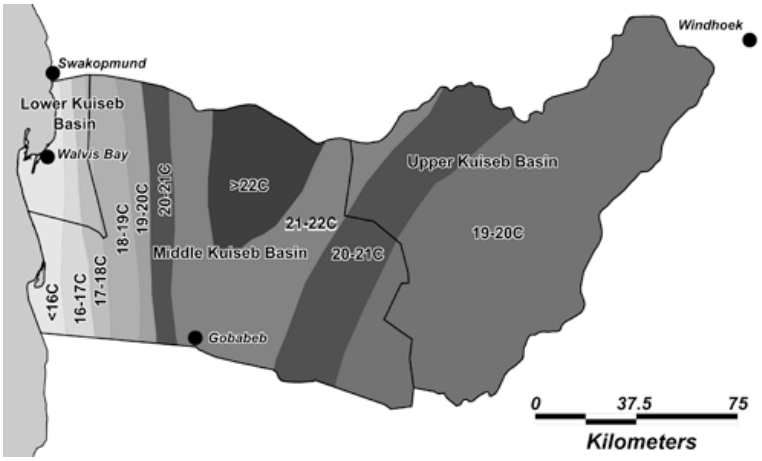

Figure 9. Average temperatures in the Kuiseb River Basin.

At Gobabeb, situated in the central Namib, temperatures are higher than in the inland. Clear skies and high radiation cause a wide daily temperature range. The hottest months, on average, are from February to April, but temperatures may reach over 40°C any month of the year.

Closer to the coast the average temperature show less variation between seasons, and the daily temperature range also decreases. The cold sea temperature and cooling effects of fog contribute to the moderate temperatures and frequent cloud cover. The average temperature in Walvis Bay is 20°C throughout the year. The warm east wind contributes to the lack of seasonal variation.

1.8 Wind

Winds in the Kuiseb River Basin are dominated by the cool southerly wind bringing in cold air from the ocean towards the desert. These winds turn into westerlies as they move inland, and can blow as far as Windhoek in the early summer months, when they are strongest. These winds commonly prevent moisture-bearing clouds from moving in from the north-east.

1.9 Wildlife in the Kuiseb River Basin

In the past wildlife used to migrate along the Kuiseb River, throughout the Basin in search for water and fodder. Since fences and camps were erected these seasonal movements of wildlife were limited. One effect of increased intensity of farming in the Basin was the improved availability of water at watering points, mainly in the upper catchment. This also made it possible for more wildlife to survive in the same area over extended time, not forcing the animals to migrate in search for water. This led to increased competition for grazing between livestock and wildlife. In the early days the farmers' response was to try to decrease wildlife numbers, as there was no financial incentive to keep it on the land. This was the situation until the 1970s when all wildlife, independent of where it was located, belonged to the government. In 1972 the legislation was changed, transferring the ownership of wildlife located on a farm to the farmer owning the farm. This resulted in farmers being able to earn money on wildlife as well as on their livestock. This provided a strong incentive for conservation of wildlife on farmland in Namibia. Permanent water points and good rangeland management resulted in steadily increasing game numbers, which had to be managed to prevent over utilisation of the rangeland. This led to the introduction of trophy hunting on some of the farms in the Kuiseb River Basin. Some farmers even ventured into managed breeding of wildlife, which is sold to game farms in order to improve the quality of wildlife on these farms. Under normal conditions game will migrate during dry periods. However, game on game fenced farms cannot migrate and therefore has a great impact on the grazing, leading to these farms often having poor rangeland. In addition, due to the poor land cover on these farms, run-off and erosion is commonly much higher compared to farms with rangeland in a better state.

B. Impacts on environment of continued land use and future development

The Kuiseb River has been the focus of life from prehistoric times until the present day (Kinahan and Pallett, 1991). Particular relationships have been forged through the convergence of water, water related resources and the different resource users within the basin. Today several different land uses are practised in the Kuiseb River Basin (Figure 10). The upper catchment is primarily used for commercial activities. IN the past commercial livestock farming used to be the most common land use there. However, recently game farming as well as tourism enterprises are becoming more common. The middle section of the basin falls within the boundaries of the Namib-Naukluft Park. The middle catchment also includes the Gobabeb Training and Research Centre as well as several settlements along the river occupied by members of the Topnaar community. The Topnaars living along the Kuiseb River practice communal farming, mainly by raising livestock and horticulture, as well as harvesting of the !Nara plant (Acanthosicyos horridus) which grows along specific stretches of the Kuiseb River. The lower section of the basin, the lower catchment encompasses the town of Walvis Bay.

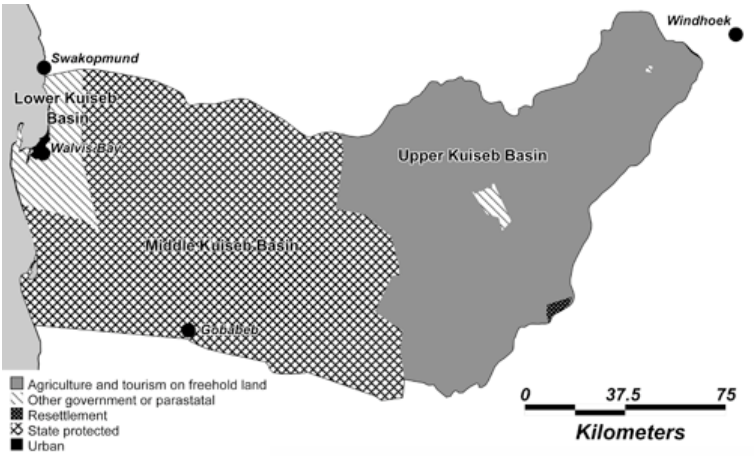

Figure 10. Land uses in the Kuiseb River Basin.

A general feature in the Basin is that areas that receive more rainfall tend to be more actively utilised. This is evident in the upper catchment of the Kuiseb River Basin where farms, mines, lodges and other land uses are many and close to each other. In the more arid parts of the basin activities are fewer and less intense. The only exception is the Topnaar communities along the Kuiseb River in the middle catchment (Figure 11). Here we can see a relatively intense utilisation of natural resources, centred on the river and surrounding vegetation.

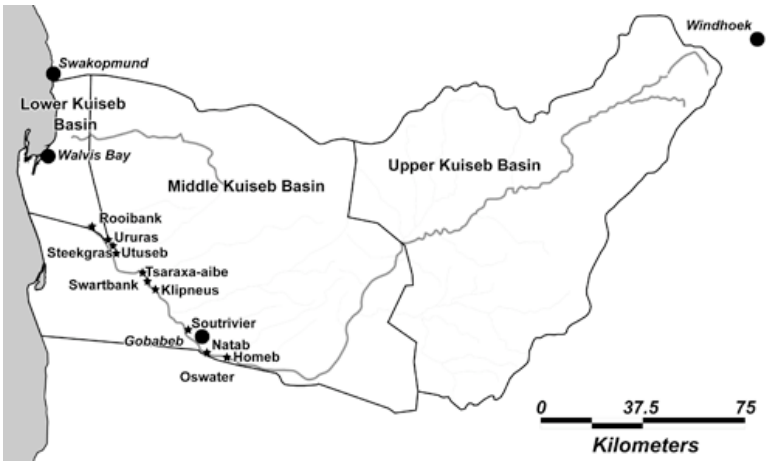

Figure 11. Location of Topnaar villages along the Kuiseb River in the middle catchment.

1.10 Commercial farming in the Kuiseb River Basin

1.11 History of commercial farming in the Kuiseb River Basin

In the early days of commercial farming in the Kuiseb River Basin there was one large company, the Liebig Company owning most of the land in the upper catchment. The Liebig Company was formed in 1907 by the Deutsche Farmgesellschaft of South West Africa. This company bought large areas of land on a nation wide scale, in order to establish a cattle farming and meat processing industry in Namibia. The Liebig Company was mainly interested in production of a meat extract called Bovril, which had an international market. What is of particular interest is that the centre of activities was at the farm Neu-Heusis some 50 km west of Windhoek well within the Kuiseb River Basin. During 1912/13 the so-called Liebig house was built in a 'turn-of-the-century' German architectural style. The house was an important stop over for travellers on the road between Windhoek and Walvis Bay. At that time the director of the Liebig Company occupied the house. Some other houses were erected on the farm, of which some are still in use by the owner of the farm. The farm had its own shop, post office, school and farrier. There was even a skittle-alley, the only one on a farm in Namibia. The Company owned land in excess of 130,000 ha in the Kuiseb River Basin, which was divided into several farms after the First World War (Schoman, 2005 and E. Hoff., personal communication, 2008). Today the house is abandoned and in a dilapidated state and said to be haunted and despite several offers the current owner has not sold it to interested parties for renovation.

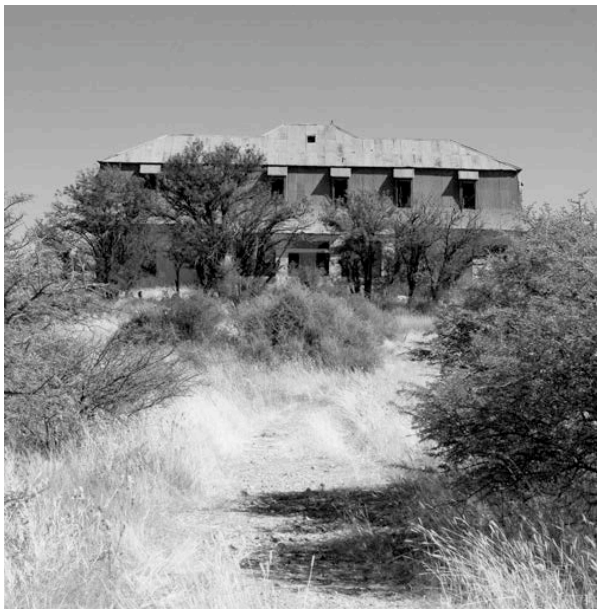

Photo 2. The Liebig house which was the headquarter of the Liebig Company.

1.12 Present day commercial farming in the Kuiseb River Basin

The first farm in the Kuiseb Basin, driving from Windhoek, is located at a height of about 1850 m.a.s.l. The most common form of agriculture in the upper catchment of the Kuiseb River Basin is large stock farming. In the upper catchment there are about 109 commercial farms (as registered on the map of the 1970s. One of the commercial farms has been bought for resettlement purposes in the Khomas Hochland; another nine farms belong to affirmative action loan scheme (AALS) farmers (MLR, 2005).

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The commercial farms are owned by about 120 farmers which employ about 400 farm workers and support approximately 2000 people in total. However, there are just a few permanent commercial farmers in the Kuiseb River Basin below the escarpment. The reason is that the dry conditions, with the high variability of rainfall between and within years, do not make farming alone financially viable. Therefore farmers have to complement their farming with a second income, most commonly

from work in Windhoek, Swakopmund or Walvis Bay. Economically speaking, productivity gradually decreases from relatively high close to Windhoek (net farm income estimated up to N$30 per ha) to very low below the escarpment, being the edge of the Namib.

As the Kuiseb River Basin is generally very rugged it is almost exclusively used for extensive large stock farming. The southern and south western parts of the Basin have also been used for small stock farming in the past when Karakul pelts were still strong in demand. Karakul sheep are the only small stock that are adapted to the extreme conditions typical for these areas and in those days many farms could make a good living on the edge of the Namib desert. Most of the farms used for Karakul farming were fenced off with jackal proof mesh wire in order to keep predators out. These fences restricted migration of game, especially along the Kuiseb River itself. The western parts of the upper catchment, as well as the middle catchment being below the escarpment and part of the Namib Naukluft Park were initially not divided into commercial farms but were used as emergency grazing for commercial farmers when droughts were encountered elsewhere. This holds true also for the rest of the western parts of Namibia. In other words much land beneath the escarpment that now has been divided into farms was former state land.

It must be noted, however, that production costs in the Khomas Hochland are far higher than elsewhere in the country.(fences, vehicles, pipelines, roads, maintenance, travel time, predators etc.).

1.13 Carrying capacity of farms in the Kuiseb River Basin

In order to make a living a farm must be able to sustainably produce a certain amount of livestock. For this a definite amount of fodder or grazing is needed per annum. In agricultural terms this is referred to as carrying capacity of the rangeland. As was stated before, the rainfall in the Kuiseb River Basin, and Namibia in general, increases from southwest to northeast. The rainfall in the Kuiseb River Basin is about 350 mm per annum in the eastern part, just outside Windhoek. Further towards the west, below the escarpment rainfall is about 100 mm per annum. The carrying capacity of the commercial farms in the area is directly correlated to the annual rainfall. The higher the rainfall the higher the carrying capacity is. According to the carrying capacity map of Namibia, a farm close to Windhoek, in the higher rainfall area would have a carrying capacity of 1:10, i.e. 10 hectares [ha] of land would provide enough fodder for one large stock unit (LSU). A farm situated on the edge of the Namib close to Solitaire has a carrying capacity of about 1:30. A large stock unit is defined as an animal weighing 450 kg.

However, nowadays carrying capacity is calculated scientifically. This more accurate calculation is expressed as kilogram grass yield per hectare (kg/ha).The available grass yield determines how many kg of meat (i.e. livestock) can be carried sustainably throughout the next year. Grazing assessments should be done annually and animal numbers adjusted accordingly. Soil characteristics also influence nutritional value as well as the carrying capacity (Figure 12) and water quality.

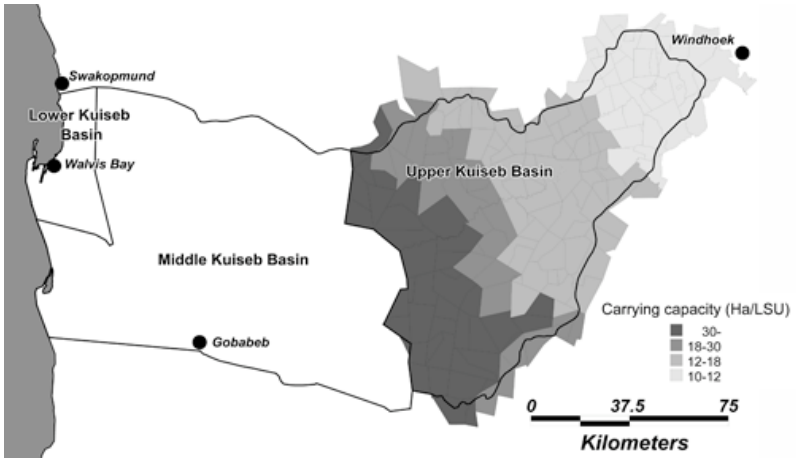

Figure 12. Carrying capacity map of the upper catchment of the Kuiseb River Basin.

In order to produce a specific number of animals (expressed as kg meat/hectare) a certain size of farmland is required. The higher the carrying capacity the smaller the farm can be for a given number of livestock (Coetzee M., personal communication 2007). The average farm size close to Windhoek is between 7 000 and 8 000 ha, while in the drier areas, where the carrying capacity is as low as 1:30, farms are commonly about 20,000 ha in size. Another aspect that influences the carrying capacity of a farm is the bush density. In the higher rainfall areas bush encroachment is commonly a problem. Bush encroachment drastically decreases the grass production due to the increased competition for soil moisture. Carrying capacity therefore decreases, which often turns economically viable farms uneconomical. In general, livestock numbers in the upper catchment have reached optimum levels. In times of drought farmers will reduce their livestock numbers on their farms by selling them or by renting alternative grazing elsewhere.

1.14 Bush encroachment

Bush encroachment is a huge problem in Namibia and also affects the Kuiseb basin. It occurs in areas with an average rainfall of 250mm per annum and more. As parts of the upper basin fall within this rainfall zone bush encroachment is also evident here (De Klerk, 2004). The main encroaching bush species are Acacia mellifera (blackthorn), Acacia reficiens (rooihaak) and acacia Erubescens (withaak). Bush encroachment is responsible for reduced water infiltration and competes directly with moisture against grasses, resulting in a less dense grass cover. In areas with heavy bush encroachment water runoff is faster and soil erosion is more severe than elsewhere which leads to faster siltation of earth dams and river beds, resulting in less recharge of underground water.

1.15 Cattle breeds

Due to the generally harsh conditions, farmers in the Kuiseb River Basin commonly make use of highly adapted cattle breeds. Cattle must be able to walk far in rocky terrain and to climb high into the mountains. A medium framed animal is therefore called for and typical breeds are Bonsmara, Simbra, Brahman, Simmentaler, Sussex, and several cross breeds of these. Furthermore, the animals must have strong mother instincts in order to raise calves under these adverse conditions and to be able to protect them from predators.

1.16 Rangeland management, the use of camps

Before colonisation only natural water points were available to humans and animals and natural resources were used in a nomadic way, as the elements permitted. Availability of water and grazing and veld fires were important factors determining the movements of these nomads. In these days there were no fences so game and livestock could roam freely. When commercial farming started, farmers became the owners of the land they occupied, fences were erected. Initially only border fences were used, demarcating the extent of each privately owned farm. Later farmers started to sub-divide their farms into smaller camps, allowing more controlled management of the grazing on the farm. Today most commercial farms are divided into camps. Camps are erected in such a way that different veld types, soil types and topographic features are separated allowing the farmer to utilise different camps during different times of the season and during specific conditions. Animals are rotated between camps in order to accommodate resting, seed production, stimulation and growth of grasses in the different camps.

1.17 Marketing of livestock (auctions in the upper catchment)

Due to the good quality of large stock production in the upper catchment (Khomas Hochland) farmers have created very sophisticated auction facilities including an electronic scale on farm Aub (Photo 3). Buyers from elsewhere in the country attend these auctions and farmers commonly obtain good prices for their animals due to the good quality and the proximity to the market.

Photo 3. Auction pen at the farm Aub.

1.18 Government and Extension services

The extension service was generally more active in the past. A key factor for this was the favourable subsidies provided to commercial farmers by the government of the day for the development of infrastructure on farmland, which started in the 1950s and came to an end in 1989. Subsidies were granted if the farmers could show that they had improved their infrastructure to an acceptable standard, something that was accessed by extension personnel. One aspect of this scheme was that commercial farmers were encouraged to establish camps on their farms, to better control grazing and to improve the management of the range. The controlling role of extension resulted in more frequent interactions between farmers and extension services compared to the present situation.

Until recently government had a very sophisticated network of extension services countrywide and also in the Kuiseb River Basin. Regular visits and courses were conducted in order to train and inform farmers about various practices, e.g. technical support, livestock production and veterinary issues. Nowadays farmers that took part in these courses and that have worked closely with extension are getting old and often move out. Today the government does not always have the capacity to deliver the services and training to the younger generation of farmers.

1.19 Water supply

The division of farms into camps also required development of water supply systems, as each camp needs access to water. This is essential in the Kuiseb River Basin as natural surface water is very scarce there. Commonly boreholes were drilled and dams constructed in river tributaries to capture run-off. However, groundwater is generally very unreliable in the Kuiseb River Basin (Christelis and Struckmeier, 2001). Therefore many farmers also constructed dams close to their boreholes. These dams supplement the boreholes with water, and also contribute to increased recharge into the aquifers tapped by the boreholes. These dams are necessary to keep boreholes going in the Khomas Hochland. Livestock drink directly from the dam as long as it contains surface water, normally only during and shortly after the rainfall season. When the dam has dried up the farmer has to rely on his borehole to water his livestock. The same applies for game in the area, when the surface water is gone, wildlife also depend on access to borehole water. This illustrates the need for farmers in the upper catchment of the Kuiseb River Basin to construct small farm dams. Without them most farms would not have enough water to sustain their animals through the dry season. As not all camps are situated on top of productive aquifers, dams are often built in areas where there is no or poor access to groundwater. Camps only supplied with dam water are

grazed before camps with boreholes. The filling up of dams and recharge of aquifers depend on the rate of runoff. Only high intensity rainfall will produce runoff. The most efficient runoff takes place when rain falls early in the rainfall season, when there is little vegetation cover. In years with plenty of plant growth, the runoff is less, leading to little water accumulation in dams and downstream aquifers. This can be described as a runoff drought.

1.20 Boreholes

Boreholes are drilled into rock formations where vaults are expected to yield a sustainable water supply. This is a difficult task as water is only carried in isolated pockets that are often missed by the drill. Creating water installations in the Khomas Hochland is far more costly than elsewhere in the country due to the topography and geological features.

The number of boreholes in the upper catchment is given as 1292 (Oosthuizen F., personal communicatoin, 2008). Due to the geological formations boreholes are generally quite deep; – up to 150 metres and more and the yield is usually weak, ranging from 200 to 2,000 litres per hour although stronger yields can be found occasionally in the upper catchment. Water quality is determined by the soil types and can sometimes be unsuitable for human and even livestock consumption

1.21 Water consumption

It is difficult to give an exact figure for water consumption of livestock in the basin, but an attempt has been made to determine livestock and game numbers in the upper basin and to calculate their minimum water requirements.

The following table shows the estimations and calculations:

The size of the commercial area, totals	962,000 ha = 9,620 km^2
Amount of farms	109
Farm size (varies)	6,000 – 20,000 ha
Average farm size	8,826ha
Recommended average stocking rate	19 kg/ha or 24 ha/LSU

Table 1: Water requirements for livestock and game within the Upper Kuiseb Basin, after M. Jakobs (personal communication, 2006).

The animal figures received were given as totals from a few farms only and had to be converted in order to try to make them representative for all the commercial farms concerned. They are as follows:

Livestock	S.S.U (small stock units)	LSU (large stock units) (1 LSU=6 SSU)
Cattle		20,345
Sheep	26,393	4,398
Goats	4,526	754
Horses		634
Mules & Donkeys		386
Total		26,517
Rounded total		30,000

Table 2: Estimated livestock numbers, upper catchment after M. Jakobs (personal communication, 2006)

At an average daily water consumption of 30l per large stock unit, the estimated total number of 30,000 large stock units in the upper catchment of the Kuiseb basin consume approximately 900 000 l/day.

Estimated game numbers and water consumption are presented in the following table

Game	Per farm (estimate)	Total number	Average daily water consumption (l)	Estimated total daily water consumption (l)
Zebra	55	5,995	12	71,940
Koedoe	40	4,360	7	30,520
Oryx	50	5,450	6	32,700
Others	10	1,090	3	3,270
Total		16,895		138,430

Table 3: Estimated game numbers and average water consumption, upper catchment, after M. Jakobs (personal communication, 2006)

It must emphasized that the water consumption figures for game represent the minimum water requirements and that game will utilize more water if available. Information was gathered through reliable resources. It must also be mentioned that game figures are based on averages and may vary from season to season. Similarly, droughts play an important role as livestock numbers will decrease drastically and game will migrate where possible.

Based on these estimates, the total annual water consumption for livestock amounts to 328,500m^3 and that for game to 50,526m^3, resulting in an overall estimated total water consumption of livestock and game of 380,000m^3 per year. To satisfy this demand approximately 3,800 reservoirs with a capacity of 100 m^3 per reservoir are needed. This amounts to an average of 35 per farm.

1.22 Farm dams

Topographical farm maps show about 750 farm dams with a total surface area of ± 12.3Mm^2 exist in the upper catchment. The combined effect of all the dams was estimated to amount to a reduction of the average flow of the Kuiseb River by 21%.The effect is higher in drier years. Dams shown on satellite images do not reveal their volume and many are silted up to such an extent that they are insignificant in terms of storage capacity and effectiveness (DRFN, 2000). Farmers do build new dams at times in order to replace old or broken dams and to develop new camps. They cost a lot of money and are only built if necessary.

1.23 Dam construction

In the Kuiseb River Basin different methods of building dams are encountered. The most common way of building dams in the upper catchment is by blocking a river by constructing an earth wall, which is referred to as an earth dam. The wall of an earth dam can be either of compacted soil or concrete where the whole structure is erected in one operation until the desired height of the wall is obtained. The dam must also have a professionally designed spillway to release surplus water (Stengel, 1963). The biggest problem with these open earth dams is evaporation. As much as 80-90% of the stored water will be lost to evaporation. Proper construction of an earth dam normally requires inputs from an engineer to design the structure. If the dam is not correctly constructed it is likely to collapse under flood conditions. A collapsed dam wall will result in stored water rapidly rushing downstream, which can cause other dams to collapse, resulting in a snowball effect of damage of infrastructure. The farmer responsible for this might be held liable if neglect can be proven.

Subsurface or sand storage dams are another type of dam. These are built by constructing a concrete wall that obstructs water, but with a maximum height of only 0.5 meters to a meter. The lower height of the dam wall will only hold back the heavier materials transported by the river, i.e. rocks and coarse sand. Finer particles, suspended in the flowing water are not trapped by the dam wall. This results in the dam being filled with coarser sediments and water, stored in the capillary

cavities under the soil surface. This limits the evaporation, allowing water to be stored in these dams for a year or even longer. Water can be abstracted by digging a well into the storage dam, or by connecting a pipeline to the dam wall, with a tap on the downstream side. When the dam basin is filled with sediments to the top of the dam wall, then the height of the wall can be increased with another 0.5-1 m, increasing the capacity of the subsurface storage dam each time the height of the wall is increased.

Other ways of obtaining water are to dig wells into riverbeds or to make use of natural springs and extract the water by pumps and then distributing it through pipelines. Another common practice is to drill boreholes into underlying aquifers. Water is commonly pumped by using windmills, solar or diesel powered pumps. The water from boreholes is then distributed via pipelines to strategic points on the farm. The major problem with drilling boreholes is that it is difficult to determine where the aquifers are. Furthermore, the quality of groundwater in the Kuiseb River Basin is often poor. Deep groundwater table and low yields of boreholes is another problem, making it uneconomic to pump.

1.24 Large scale dams

In the upper reaches of the Kuiseb River, on farm Friedenau there is an active copper mine, named Matchless Mine. This mine is part of the Ongopolo Mine. In order to supply the mine with water the Friedenau dam was built in the upper part of the Kuiseb River (Photo 4). The dam has a large storage capacity but is not big enough to contribute to the water supply of Windhoek, which has led to the dam being criticised. The critique was most prominent during 1983 and 2005 when the Matchless Mine was closed and no mining took place. Presently only the mine and a few adjacent farms make use of the water in the dam. Until recently Ministry of Basic Education, Sport and Culture had a facility here, which has been abandoned. Now the dam is the venue for a lodge and campsite named Hochland Nest.

Photo 4. The Friedenau Dam close to windhoek.

1.25 Communal farming in the Kuiseb River Basin

The Topnaar community traditionally occupied the lower reaches of the middle Kuiseb River catchment. Today they are residing along the Kuiseb River and their settlements are located from Rooibank (about 40 km east of Walvis Bay) to Homeb (about 140 km east of Walvis Bay). There are 18 Topnaar villages along the Kuiseb River (Figure 11). The total population of Topnaars along the Kuiseb River is about 300. The Topnaars are led by their headman, Chief Kooitjie. The inhabitants of the Topnaar settlements along the Kuiseb River are commonly pensioners and young children. Many of the youth and the middle aged family members are staying in the coastal

towns where they are attending school or working. The inflow of money and goods from the towns seems to be a central aspect of the livelihoods of the Topnaars living in the Namib-Naukluft Park.

Farming takes place along the Kuiseb River, mainly with approximately 200 cattle, 2,500 goats, 120 donkeys and about 50 sheep (Kooitjie J., personal communication, 2008). The only source of fodder for the livestock comes from the riverine forest, supplying pods and leaves. The most common trees are Faidherbia albida (Ana tree), Acacia erioloba (Camel thorn), Euclea undulata (Fake Ebony). The Ana tree and the Camel thorn have different production cycles, i.e. the one is dormant while the other flowers and bears fruits. This ensures a regular supply of fodder. An interesting aspect of this high dependency on the pods from the Ana tree is that farmers commonly experience a 'drought' situation, i.e. lack of fodder for their livestock during and after a flood event as the pods are washed away, leaving less fodder available for the animals. Livestock movements are mainly restricted to the riverbed and riverbanks as the sand dunes to the south and the gravel plains to the north do not offer any significant amounts of fodder.

Livestock is commonly kept and bred with the objective to maximise the herd size rather than for regular marketing. Generally, livestock is only sold when there is an immediate need for money, e.g. for school fees, weddings and funerals. There are no reliable statistics for how many livestock there are in these communities. The small stock is of indigenous breeds and large stock is commonly a mix of European breeds and indigenous Sanga cattle. Donkeys are kept for transport purposes.

1.26 Harvesting of the !Nara melons

Apart from the livestock keeping the Topnaars are harvesting and processing the !nara plant, which produces a spiky melon like fruit. Traditionally !nara plants/ fields were demarcated and individual plants owned by families. This system is now falling apart, being transformed into an open access system, in which everyone is in competition for the !nara fruits. In the early 1990s the average !nara yield was estimated to be 26,000kg. However, the total harvest volume declined by 30% during the 1990s. The decrease has been explained by declining interest in !nara business due to a lack of market incentives for the !nara harvesters. Another reason could be a decline in !nara productivity, something that has been claimed by both Topnaars and researchers investigating the ecology of the !nara plant (Henschel et al., 2004). The trend of workable members of the community moving to the towns could also be a contributing factor. Furthermore, change in harvesting methods and the shift from private ownership to communal commodity can also have led to the decreased production.

Photo 5. !Nara plant in the Namib Desert, close to the Kuiseb River.

The Topnaars role in the !nara market is commonly restricted to the supply of raw material, i.e. !nara pits, and they are seldom involved in the further processing, value-adding and profit-making which is done by other entrepreneurs.

1.27 Water supply to the Topnaar communities

Earlier the Topnaar communities were depending on hand dug wells, which were dug in or close to the riverbed of the Kuiseb River for their water supply. The water table was originally shallow in this part of the Basin. However, in response to increased utilisation of the Kuiseb aquifer by mainly Rössing mine and Walvis Bay, the wells dried up, which not only resulted in problems with water supply for the Topnaars but also for trees and !Nara plants, resulting in some trees and plants dying. This was first documented in the 1970s. The lowering of the water table led to many hand dug wells being abandoned. As there was not enough water from the hand dug wells to sustain the livestock, a number of boreholes were drilled and infrastructure was put in place by the government at each of the Topnaar settlements. According to the present water policy, rural communities are expected to pay for the supply of water, something that the Topnaars have never done before, and therefore do not have the socio-economic mechanisms in place to do. This is an increasing problem, placing communities in debt to the water providers, which threatens the water supply to these settlements. This is an issue that needs to be addressed by Rural Water Supplies and the leaders of the Topnaar community.

One factor that is limiting the inhabitants of the Topnaar communities is that they live in a national park. This places restrictions on hunting game for consumption. However, some representatives from the Topnaar community are venturing into the field of ecotourism, which would make these communities less dependant on their livestock. Some Topnaars are consulted and contracted by tourism operators offering dune trips in the area. This development can lead to additional incomes to the Topnaar communities along the Kuiseb River, making them less dependant on the traditional farming practices.

1.28 Diversification of the agricultural sector in the Kuiseb River Basin

Several farmers have diversified their livelihoods by delivering various services to the farming community and the private sector countrywide (Hongslo and Benjaminsen, 2002). Some are drilling boreholes for other farmers or government and mines, while others are offering services like design and construction of water supply systems, maintenance of farm roads and building and maintaining earth dams. Three farmers do horse breeding for an extra income, very successfully and also sell and compete internationally. Many farmers close to Windhoek are working in town during the weekdays, commuting to work every day.

In the southern part of the lower catchment, the Gaub area rainfall is lower than in the northern part, making agriculture less financial viable. Instead of farming many landowners in that part of the basin are more involved in tourism than in agriculture. Some landowners that are still farming in these low rainfall areas are returning to farming with Karakul sheep. A practice that recently has increased as the market and therefore the price of pelts has increased. The Karakul industry collapsed in the 1980s. At the same time tourism gained momentum, especially in the western, more arid parts of Namibia, which have shown a great potential for tourism. This has resulted in many farms being turned into guest farms and hunting farms. The Kuiseb River basin has a great potential for these two forms of diversification. The farms closest to Windhoek are mainly doing cattle farming but many also offer game viewing and hunting. The farms below the escarpment are highly sought after by tourists due to the scenic landscape and their proximity to both Sossus vlei and the coastal recreation facilities. Several tourist operators are taking tourists into the Namib-Naukluft Park, and to other parts of the Basin. Most of these are marketing their ventures as eco-tourism, e.g. Mola - Mola, Uri Adventures, Charlie’s Desert Tours, Dare Devil and more.

When diversifying into game farming, livestock numbers are usually decreased, in order to accommodate larger game numbers. This implies that less water will be used as game needs less

water to survive than domestic livestock does. When diversifying into tourism, game and livestock numbers usually stay the same, but more water will be used for guests and gardens around the homestead. An estimated figure of 200 litres per person per day is accepted. Gardens on guest farms tend to be bigger than on normal farms and swimming pools are common,

More than 40% of farms in the basin have diversified into tourism and hunting.

1.29 Conservancies in the Kuiseb River basin

Today there are two conservancies in the basin, the Auas-Oanob and Khomas Hochland which are active in the upper catchment and responsible for sustainable game and rangeland management.

1.30 Schools in the Kuiseb River basin

There are two schools within the basin. These schools are mainly for children from the farms. One school is situated about 30 km west of Windhoek on farm Baumgartsbrunn, which is a private initiative from the farm owner. The school is funded by the Friedrich Ebert Stiftung in Germany. The other school is located in Uduseb, a village situated about 50 km east of Walvis Bay, in the desert, next to the Kuiseb River. This school serves the children from the Topnaar communities living along the river. The government operates the school. Some farmers on the commercial farms also make use of the home schooling system, where the farmers themselves provide the schooling of their children, following a syllabus defined by the Ministry of Education.

1.31 Mines

Apart from the Matchless Mine just outside Windhoek in the upper catchment there are two more mines in the middle catchment, being the Gorob and Hope Mine. They are mining for copper. Several granite quarries are situated outside Walvis Bay along the road to Rooibank (Figure 13).

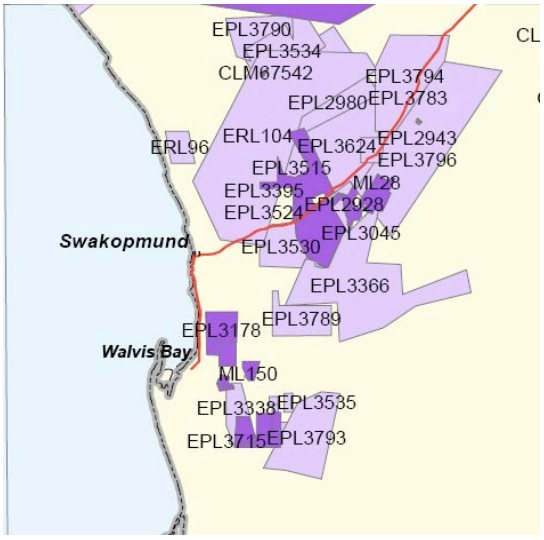

Figure 13. Map showing the location of granite quarries in the lower and middle catchment.

1.32 Lodges in the Kuiseb River basin

Next to the Friedenau dam a lodge has been established, the Hochland Nest Lodge and Campsite. The attractions here range from scenery, fishing game drives and camping. In addition, a wellness centre has been developed on the farm Weissenfels. It also offers horse trails to tourists. Another farmer offers horse and camel safaris in the Kuiseb River basin.

1.33 Observatories

Due to the altitude, commonly clear skies and the location on the southern hemisphere, Namibia is world famous for its stargazing potential. This has also led to the construction of several advanced

astronomic observatories in the Kuiseb River basin. Max Planck Institute has established an observatory on top of the Gamsberg Plateau (2347 m.a.s.l.). A second advanced observatory has been constructed on farm Göllschau close to the Gamsberg, the HESS Project. This observatory is monitoring the gamma radiation from outer space. Both these initiatives have provided opportunities for alternative incomes for the farmers in the area.

C. Environmental issues to be addressed

There are several gaps and shortcomings related to the agricultural sector in the Kusieb River Basin. The impact of earth dams, constructed on commercial farms in the upper catchment has been a central issue in the Kuiseb River Basin. There have been some studies of this, e.g. the Summer Desertification Programme 9 (DRFN, 2001). However, there is still a lack of understanding of the effects of earth dams on floods and runoff in the Basin. Another aspect of earth dams that would need further investigation is the siltation rate of these dams. Presently we do not know how much dams silt up after various rainy seasons and how their storage capacities decrease up to a point where evaporation will take up all the water within one year, i.e. before the next rainfall season.

The main problems farmers are faced with are: bush encroachment, high evaporation rates of dams, veld fires, droughts, meat prices, predators, land reform, water quality, high production costs, age of farmers who are not allowed to sell or transfer their farms to their children, high maintenance costs for infrastructure, lack of advice by qualified extension personnel, illness among livestock. The recent interest in uranium mining in the Kuiseb River Basin will also affect a few farms in the upper catchment, in particular the farms bordering to the Namib Naukluft Park. Due to the developing tourism industry many farms have changed from cattle farming to tourism or a combination of both. Water consumption is lower by tourists compared to livestock. The most central issues are summarised in Table 4 below.

Table 4. Gaps and shortcomings within the agricultural sector in the Kuiseb River Basin.

Field	Impact on the agricultural sector and the environment in general
Commercial farming	Earth dams May have a negative effect on water supply downstream No up to date information about how many earth dams there are in the Kuiseb River Basin High siltation rate in earth dams, makes lifespan of dams short and rapidly declining capacity Causing less runoff, most noticeable during drier years High evaporation rate
	Water reservoirs Groundwater stored in open reservoirs results in increased evaporation
	Overgrazing Can cause bush encroachment Causes degradation of rangelands Leads to increased runoff, increased erosion and increased siltation of earth dams
	Game farming When wildlife is fenced in they cause extensive degradation of rangeland Overutilisation of key species of grasses and shrubs Incest commonly occurs if breeding not controlled
Communal	Water supply

farming	Several issues related to payment of water Lowering of the water table due to extraction by Namwater Poor quality of groundwater at places
	Diversification Need to identify alternative income sources to limit dependence on livestock and !Nara melons
	Livestock Change in traditional farming systems to be more market orientated
Extension services	Limited resources Lack of manpower and expertise to serve the farmers in the Kuiseb River Basin
Tourism	Does not have much direct impact on the farming environment, except: Diversification of income can allow farmers to keep less livestock on the rangeland Job creation possible Worth noting that off-road driving on the gravel plains in the middle and lower catchment can cause irreparable damage to the environment Desert is very sensitive and can only accommodate a certain amount of controlled tourism activities Guest farms usually have pools and lush gardens around the house,- need more water for that industry.
Mining	Heavy impact on the environment through pipelines, power lines, roads, actual mining activities, poaching, theft on surrounding farms There are possibilities of uranium mines being established on farms in below the escarpment, which can have high financial gains but also adverse impacts on the environment
Large scale dams	Do alter the flow pattern of the Kuiseb River Can create new recreational facilities and job opportunities Will require construction of pipelines to transport water to Windhoek and Walvis Bay Will require construction of new power lines that will have a negative influence on the scenery, i.e. touristic value will decrease
Resettlement farms	Sustainability Most resettlement farmers have limited financial means and lack experience of farming in this part of Namibia Resettled farmers do not have proof of ownership of farm and thus have no security to borrow money for farming purposes Infrastructure cannot be maintained due to limited resources Limited predator control often leads to greater livestock losses There is a definite need for training in terms of basic farming methods, financial management and record keeping.
New trans-Kalahari	More traffic Scenery disturbed/destroyed

highway via Us pass	New business opportunities Less tranquillity but new opportunities for guest farms
Large scale water abstraction	Negative impact on groundwater levels, leading to hand dug wells drying up Trees and !Nara plants have been shown to die
Alien vegetation	Prosopis spp. Is encountered throughout the basin, present on every commercial farm Seeds and pods are washed downstream Very drought resistant plant, making it a strong encroacher So far Prosopis is not a major threat in the Kuiseb River Basin, but its presence is increasing
	Wild tobacco (Nicotiana glauca) Poisonous plant which can form thick stands with a deep root system Mainly found downstream in the middle and lower catchment
	Thorny apple (Datura spp.) Poisonous plant with a shallow root system
	Rhizinus (Richinus communis) Poisonous plant with a shallow root system

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