











AGRICULTURAL ASSESSMENT OF THE BAVIAANSKLOOF

REPORT PREPARED FOR

GREENCHOICE

AN INITIATIVE OF

CONSERVATION SOUTH AFRICA

IN COLLABORATION WITH

LIVING LANDS / PRESENCE

06 AUGUST 2012

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Declaration of Independence

This report was compiled by François H Knight, principal consultant at Agri Informatics. Mr Knight holds a B.Sc.Agric.Hons degree in Soil Science from the Free State University, a post graduate diploma in terrain evaluation from Potchefstroom University and a M.Sc.Agric.*cum laude* degree in Soil Science from the University of Stellenbosch. He has more than 20 years experience in natural agricultural resource assessments, which stems from his work as a senior researcher at the Department of Agriculture and, for the past 10 years, as an independent consultant.

Mr Knight has no business, financial, personal or other interests in the agricultural or conservation activities of the Baviaanskloof, other than fair remuneration for work performed in connection with this study and there are no circumstances that may compromise the objectivity of his work.

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Contents

1. Summary

The Baviaanskloof is an isolated and truly unique valley, both in terms of ecology and agriculture. Commercial farming in the form of cultivation and livestock has a history of about 250 years in the Baviaanskloof and reached a peak in the mid 20th century, when up to 2000 people lived in the valley. Today, there are still about 20 operational farms.

The conversion of large tracts of land to formal conservation areas, during the past few decades coincided with a downscaling in agricultural activity. Extensive small stock farming in the mountain areas has practically been terminated, whilst the earlier thriving vegetable seed industry has been reduced to a few farms only. This study found a reduction of 26% in cultivated area from the former 1006 ha to the present ±740 ha. Economic constraints such as high input costs and low producer prices have been indicated as main reasons for downscaling in crop production, whilst predation is the main cause of the termination of extensive small stock farming.

The climate of the valley is suitable for the production of a wide range of crops, whilst the few soil limitations of layering and low water retention can easily be modified or managed. The rainfall is however not sufficient or reliable enough for any dry land cultivation and irrigation is therefore essential for all crops. The annual water abstraction for irrigation, from the alluvial aquifer is estimated at 3.3m m^3 or ±40% of the annual recharge (7.9m m^3) of this aquifer alone. The annual recharge of the entire catchment (Alluvial aquifer + Table Mountain Group aquifer) is conservatively estimated at more than 18m m^3.

In a scenario where all recently cultivated fields (741 ha) are planted to irrigated pastures, the theoretical carrying capacity of the valley would amount to 2954 large stock units – 730 on the mountain veld and 2224 on the irrigated pastures. The irrigation requirement would however increase to 8.8 m m^3/a, which exceeds the estimated recharge of the Alluvial aquifer, thus implying non-sustainability, when no connectivity between the two aquifers is assumed.

An analysis of the resource potential of each of the remaining 21 farms, indicated that only 7 farms have more than 40 ha of arable land and only one farm has more than 100 ha. The sustainability of the remaining farms is therefore limited by available arable land, economic viability and logistical support, more than by the quality of the natural resources of climate, water and soil. The viability of existing crop production is expected to further diminish over the next few years due to escalating input costs, while the full conversion to livestock (irrigated pastures) is also not viable both in terms of its high water requirement and limited stock numbers on most farms.

Further transformation of land to nature reserves and the breeding of high value game species are under consideration and should be further explored. Future crop farming in the Baviaanskloof will increasingly rely on high value crops, value adding and niche markets to attain sustainability. Possible alternative crop examples are liked to tourism and/or product exclusivity and could include wine (grapes and a cellar), essential oil (growing and extraction) or even a cigar factory. Further development of the existing eco/agri-tourism opportunity is expected to provide the backbone of the economy. The isolation and uniqueness of the Baviaanskloof should be exploited to its full extent to differentiate its products in the market place.

2. Introduction

The Baviaanskloof, in the Eastern Cape of South Africa, is a long narrow valley of approximately 100 km from the Nuwekloof pass in the west to Patensie in the east. The altitude difference over this distance is almost 940 m and the vegetation changes from typical Succulent and Nama Karoo to Subtropical Thicket, with Fynbos, Grassland, Savanna and Forest Biomes along the way – a result of the altitude, climate and geological differences.

Access into the valley is either via the Nuwekloof Pass in the west or the Baviaanskloof Nature Reserve in the east. The western access is serviced by a good gravel road with Willowmore the nearest town, 78 km (1:20 h) from the centre of the farming community at Studtis. The eastern access through the Wilderness Area is a minor gravel road, traversing a series of steep passes – built by Tomas Bain in 1890 – and water crossings, mostly impassable after good rain. The nearest town at this side of the Baviaanskloof is Patensie, 133 km (up to 4 hours drive) from Studtis.

European farmers settled in the valley in the mid to late 18th century and a community of up to 2000 people made a living as farmers or labourers from livestock and crops until the mid 20th century. The continuous acquisition of land in key habitats to provide formal protection has imposed a strong conservation character onto the Baviaanskloof and has lead to a transformation of unviable farms to protected area during the past few decades (Boshof, 2005). At present there are still about 20 operational farms in the valley, fully enclosed by formal nature reserves. Most farmers have also adopted conservation priorities and brought nature friendly practices to their farms, like leopard friendly livestock farming and veld restoration (spekboom planting) projects. Many have also introduced eco tourism facilities, mainly in the form of tourist accommodation and allowing tourists hiking and leisuring on their farms.

Increasingly adverse economic conditions and the remoteness of the Baviaanskloof has made it very challenging to farm profitably and has opened the opportunity for stronger integration between farming activities and conservation goals, resulting in the Baviaanskloof Hartland Initiative – a joint venture between local farmers and conservationists, seeking to find sustainable alternative land use options. This study was commissioned as a result of this initiative and seeks to provide an overview of the agricultural resources, document the *status quo* of the farming activities and assess the sustainability of present and possibly also alternative farming activities, with the aim of using this information to further the objectives of the Hartland Initiative.

3. Terms of Reference

Conservation South Africa hosts the Green Choice Alliance secretariat. Green Choice has entered into an agreement with Presence, a NGO operating in the Eastern Cape. In agreement with Presence, Green Choice wishes to facilitate an Agricultural and Conservation Planning study for and with farmers of the Baviaanskloof Hartlands Initiative (BHI). These farmers have expressed their wish to change their present land use where appropriate, from crop and livestock farming, to more sustainable farming and wildlife/ecotourism and restoration. With a group of experts in soil, agriculture, conservation planning, wild life and ecology of Subtropical Thicket, Green Choice wishes to further develop the existing land use plan of the area.

For this purpose, Green Choice has contracted Agri Informatics to assist with the agricultural zoning of the area. Green Choice requires Agri Informatics to make use of existing knowledge (articles, SEON maps of the Baviaanskloof, soil nutrient data, access to Presence and CSA staff, other members of the group) and data gathered from representative sites (to be chosen by the group, but being restricted to floodplain soils which are suitable for agriculture) during a 3-5 day field trip in the Baviaanskloof area in order to:

1. Assess, with the group, designated areas for **suitability of growing present crops** of maize, lucerne, wheat, olives in a sustainable way (wrt to available water, chemical inputs, topography, **potential conflicts** with other land uses and wildlife needs, as well as human and wildlife conflicts) and delineate these on a map layer;
2. In particular, to advise on the most suitable areas for **scaling up the high value seed growing activities** (onion, carrot) in a sustainable way (as above) and indicate these on a map;
3. Advise on any **other high value crops** which would be suited to the soils, topography and microclimate etc while not posing a sustainability risk and indicate these on a map;
4. Record sites assessed as points on a map layer;
5. Where possible, give **input to discussions around carrying capacity** of areas of livestock presently farmed;
6. Participate in developing a **first draft of an Agricultural and Conservation Plan** for the BHI; and
7. Be willing to participate in the development of the final Agricultural and Conservation Plan for the BHI, either as a workshop, or remotely as required.

4. Study Area

The catchment area of the Baviaanskloof River (Figure 1) was identified as the wider study area, but for the purpose of this Agri Zoning study, it was limited to the farm land in the valley (Figure 2).

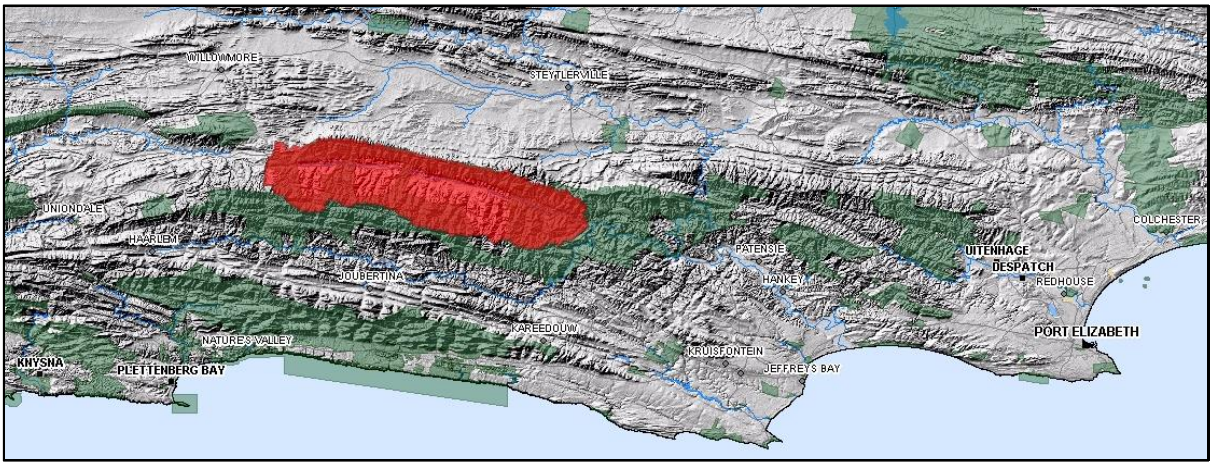


Figure 1: Baviaanskloof (red), surrounded by steep mountain ranges, is situated between the Willowmore-Steytlerville Karoo in the north and the Langkloof in the south.

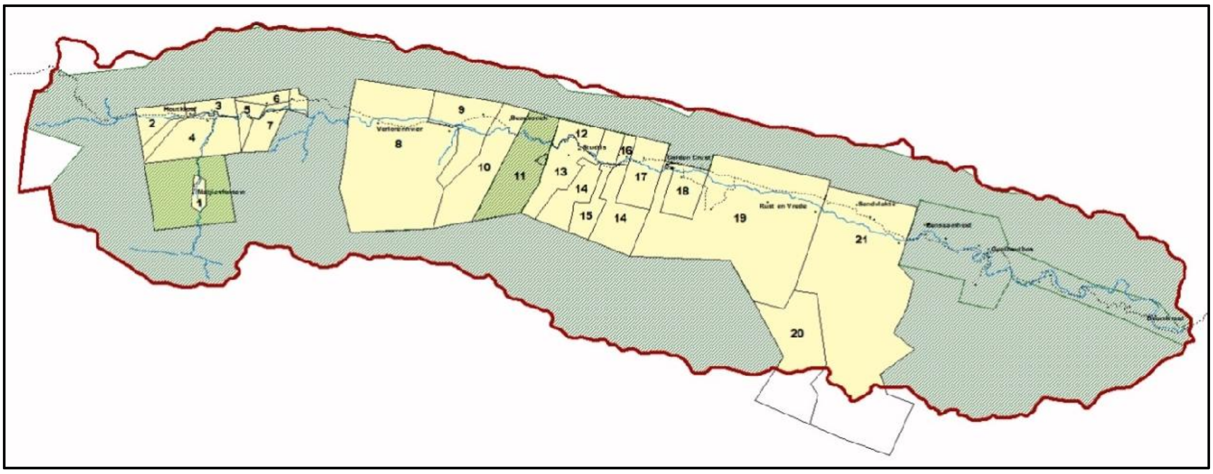


Figure 2: The farm land (light yellow) that formed the study area. Shades of green are formally protected areas or private nature reserves.

A total of 21 farm units have been identified, consisting of up to 89 land portions with a combined area of 44 143 ha, according to the spatial data provided by the Surveyor General. The terms of reference also specifically mentioned the arable floodplains as the focus area of the Agri Zoning study.

NOTE: *All maps presented in this report are available as GIS data layers in either ESRI shapefile format or as GeoTiff raster images. Although the area spans two UTM Zones (34 & 35) all data are projected UTM35 to conform with the projection used by Presence. All surface areas were however calculated using WGS84 spheroid, Hartbeesthoek 1994 datum and Transverse Mercator projection with Central Meridian 23° east for the part of the study area west of 24° longitude and Central Meridian 25° east for the part of the study area east of 24° longitude.*

5. Study Methodology

In this report, *agricultural potential* is regarded as the result of (i) the combination of the **natural resources** – climate, water, soil, vegetation and also the effect of topography on microclimate – and (ii) the **market conditions**, which in turn includes the normal drivers of production cost versus producer price, but also to the access to the market and market stability. Not all of these factors could be analysed in detail for this study and also were not included in the terms of reference. **The aim was rather to identify critical constraints and perhaps identify new opportunities** that could introduce more sustainable agricultural activities. Against this background, the study entailed (i) an overview of existing data and information, (ii) a site visit and reconnaissance soil survey conducted over 4 days during June 2012 and (iii) a desktop analysis and spatial modeling, to derive the findings and recommendations. The following structure was therefore used to present the findings:

- Current and historic land use
- Topography
- Climate
- Water
- Soils

- Grazing
- Sustainability
- Alternatives

6. Current and Historic Land Use

Historically, agricultural land use in the Baviaanskloof typically included livestock farming (mainly sheep, angora goats, boerbok, cattle and/or ostrich), where the mountain land was mostly used as extensive grazing for adult animals, while lactating ewes and young animals will be kept on planted, irrigated pastures (lucerne) on the valley floor. A reliable supply of good quality groundwater was also used for the production of a variety of predominantly, annual crops on the alluvial soils along the Baviaanskloof River. Vegetable seed production (onion, leek, carrot, pumpkin) used to be a flourishing industry. The valley is ideal for seed production as it is geographically very isolated and therefore has a low risk for cross pollination and disease transfer. Other crops included tobacco, small grains, maize, vegetables and some small plantings of stone fruit (apricot), citrus and avocado. Several strategic changes to farming conditions in the past few decades, lead to drastic changes in the land use pattern of the Baviaanskloof. This became evident from interviews held with seven of the farmers in the valley during the field visit and is also confirmed by an analysis of recent aerial imagery.

High resolution imagery of 2009 in conjunction with some observations during the field trip, were used to delineate all recognisable cultivated fields. Four categories were assigned to distinguish between currently productive fields and fields that were used in the past:

	**Abandoned Field** <u>Description:</u> Obvious signs of regrowth including large shrubs and trees. Estimated that these fields have not been cultivated in the past 5 or more years. <u>Implication:</u> Assumed that it was abandoned due to poor crop performance leading to non-viability and thus not sustainable.
	**Old Field** <u>Description:</u> Obvious signs of regrowth but without large shrubs and trees. Estimated that these fields have not been cultivated in the past 2 to 3 years. <u>Implication:</u> Assumed that it was not cultivated recently, due to current non-viability. A change in economic conditions could bring these fields back into production.

Recently Cultivated Field

Description:

Obvious signs of recent cultivation, but without a current crop. Considered part of a crop rotation system.

Implication:

These fields are part of the present production system.

Productive Field

Description:

Fields with a current crop.

Implication:

These fields are part of the present production system.

This analysis resulted in the statistics shown in Table 1 and also Map 1: Land Use Map (Appendix).

Table 1: Summary of cultivated fields on each of the 21 farm units.

Farm	Total Area (ha)	Abandoned Fields (ha)	Old Fields (ha)	Recently Cultivated (ha)	Productive Fields (ha)	Total (ha)
1	206			19.7	6.1	25.8
2	547	42.5		2.3	0.3	45.1
3	565			7.3	7.9	15.2
4	1481			45.2	40.4	85.6
5	326	No cultivation				
6	347		6.1		2.0	8.1
7	689		2.1		1.7	3.8
8	6610	9.6	6.7	30.3	31.5	78.1
9	1566			8.4	35.8	44.1
10	1963			7.3	28.1	35.4
11	2008	Converted to private nature reserve				
12	500			11.7	12.6	24.3
13	1416	17.4	5.6	8.4	78.4	109.9
14	2167	5.8	8.6		25.7	40.0
15	613	16.8				16.8
16	179	1.1				1.1
17	1117			1.4	28.3	29.7
18	823	2.6	19.4	5.5	64.1	91.7
19	7899	54.9	39.0	0.9	185.4	280.3
20	2810	No cultivation				
21	10311	22.9	37.6	44.7		105.2
Total[1]	**44143**	**173.6**	**91.0**	**193.1**	**548.3**	**1006.0**
Total[2]	**40800**					

NOTE: 1072 ha of farm 20 and 2271 ha of farm 21 falls outside of the Baviaans River catchment. Thus the total of the cadastral farm portions is 44143 ha (Total[1]), but the total farm area inside the catchment is only 44800 ha (Total[2]).

The area of the farm land in the Baviaanskloof, 40 800 ha [i.e. 44 143 – (1072 + 2271)] is only about 37 % of the total area of 121 725 ha of the catchment. Apart from the farm land, only ±2000 ha is not included in a formally protected area, while Farm 11 (2008 ha) has been converted to a private nature reserve. The ratio of conservation land vs farm land is thus 80 933 : 38 792 or 2:1.

The total area historically cultivated in the Baviaanskloof (i.e. 1006 ha) accounts for only 2.3 % of the total farm area of the 21 farm units identified in this study. Out of the 1006 ha of previously cultivated land in the Baviaanskloof, only ±740 ha appears to be cultivated productively at present. This amounts to a 26% reduction in cultivated area. [Other studies reported 808 ha irrigated and 1071 ha dry land or old cultivated fields (Mander *et al*, 2010); 300 ha irrigated (Illgner & Haigh, 2003, as cited in Jansen, 2008); 468 ha irrigated (Jansen, 2008) and 1400 ha irrigated (DWA, 2002, as cited in Jansen, 2008)]. Seven main reasons for the reduction in cultivation were offered during the interviews:

Reduced profitability of vegetable seed production. Historically the Baviaanskloof was a sought after vegetable seed production area. More seed companies, stronger market competition and high quality requirements (germination percentage) has reduced the profitability to the extent that only a very few farmers still produce vegetable seed and only on a small scale.

Non viability of cash crop production. High input and transport costs and marginal producer prices has effectively terminated small grain production, while vegetables (potatoes) are only produced by one or two farmers for the Willowmore market. Wheat and maize are mostly planted to be used in animal feed rations.

High electricity cost. Most farmers have made the transition from flood irrigation to more efficient sprinkler (mostly centre pivots and quick coupling moveable systems). As these systems (mostly) require the water to be pumped, the escalating cost of electricity are adding another significant component to the already high cost of production. Some famers are now only irrigating low lying fields that can be irrigated under gravitation – thus without pumping the water.

Crop damage by monkeys, birds and baboons. The close proximity of the conservation areas that offer safety and shelter to birds and primates in combination with the relatively small crop production areas often lead to a concentration of problem animals and potentially significant crop losses.

High stock losses induced by jackal and caracal predation. All farmers indicate that jackal and caracal numbers are now much higher than in earlier decades, due to the protected status of the land surrounding their farms. Most farmers appear to have accepted this fact – contrary to many farmers elsewhere in the Karoo – and have adapted their stock farming practices as far as possible. This entails in most cases a reduction in small stock numbers, as they no more utilise the mountain veld for extensive grazing and those who do, will only put mature animals of large breeds out in the veld. Anatolian shepherd dogs are used by some farmers but with mixed success. Leopard predation was not mentioned as a major problem and almost all farms display "leopard friendly" signs of the Landmark Foundation.

Insufficient irrigation water. Only one farmer (Farm 21) has indicated that a lack of irrigation water contributed to their decision to cease all cultivation.

Alluvial fans. A change in understanding of the ecosystems function of Alluvial fans, especially as an infiltration zone for feeding into the groundwater, has lead to the reinstatement of old flow patterns, previously cut off by diverting structures to protect fields against flooding.

7. Topography

The Baviaanskloof is a valley in the Cape Fold Mountains, parallel to the coast line, but separated from the coastal plain by two mountain ranges, the Tsitsikamma Mountains and the Kouga Mountains. The latter forming the southern boundary of the Baviaanskloof and is less steep but higher than the northern range, the Baviaanskloof Mountains (Figures 3 & 6).

An analysis of the topography of the study area has been conducted, making use of GIS (Geographic Information System) technology and a digital elevation model (DEM), compiled from the 20m-contour data of the 1:50 000 map series supplied by NGI (Map 2: Digital Elevation Model, Appendix). The elevation difference between the lowest and highest farm is almost 500 m over a distance of ±50 km, thus a slope gradient of only 1 %. Figure 4, provides a cross section in the valley bottom, from west to east, over the length of the study area and Figure 5, a south to north cross section in the vicinity of Studtis.

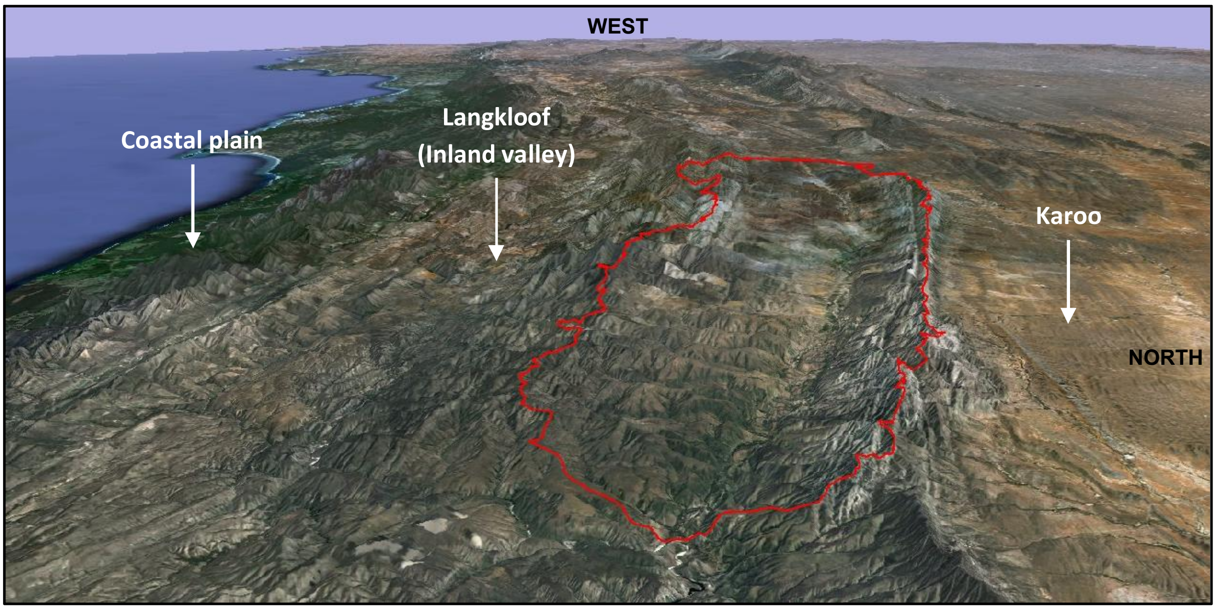


Figure 3: Panoramic view over the Baviaanskloof study area (red line). Note the three mountain ranges parallel to the coastline (GoogleEarth, 2012).

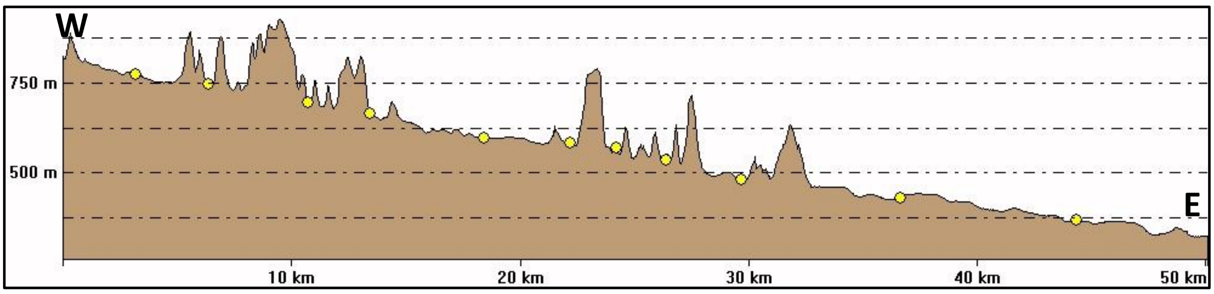


Figure 4: A length-wise section along the valley, from west to east, indicating the approximately constant slope of the valley floor of about 1%.

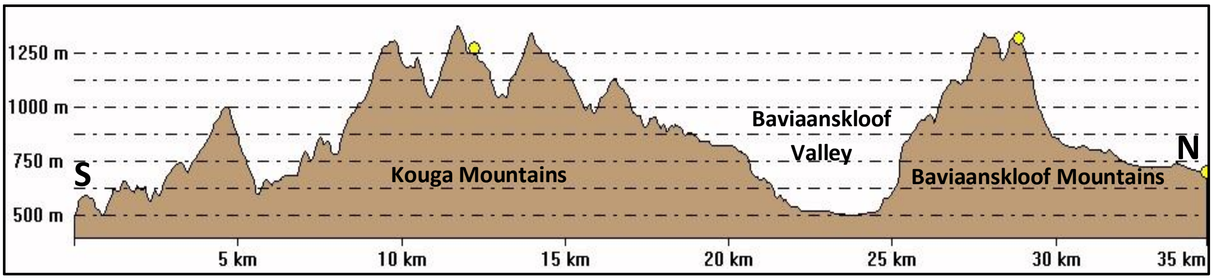


Figure 5: A cross section through the valley in the vicinity of Studtis, from south to north, indicating the peaks of the Kouga Mountains and the steep slopes of the Baviaanskloof Mountains.

Figure 6: Cultivated fields in the eastern part of the study area. Note the steeper slopes on the northern (right) Baviaanskloof Mountain range (GoogleEarth, 2012).

From Figure 6 it is expected that the steep Baviaanskloof Mountain range could have a significant shadowing effect on the valley during winter when the sun's azimuth (angle east or west of north) and altitude (angle above the horizontal) are low and the days are short. This effect may have an impact on a winter ripening crop, such as olives. The extent of this impact is however uncertain, but as Studtis (Kamerkloof) is the only farm with a commercial planting of a perennial crop (12 ha olives) and is in close proximity to the mountain – where the effect will be highest – it was decided to conduct solar radiation modeling to quantify the potential difference in solar radiation. This GIS modeling (Solar Analyst) follows the trajectory of the sun (Figure 7) and calculates the incoming radiation flux relative to the land surface at any locality and for any date, on a predetermined time step. The results are presented in Figure 8.

The late sunrise and early sunset in winter at Studtis is confirmed by the model, while the peak radiation at Beacosnek is the lowest of the three localities. A summation of the total solar radiation indicates that both Studtis and Beacosnek receives ±90% of the value calculated for Doornkloof – or about 10% less, due to the effect of the topography. The perceived effect thus appears smaller than anticipated, but the shorter duration of direct sunshine by 2 to 2.5 hours at Kamerkloof is expected to be significant.

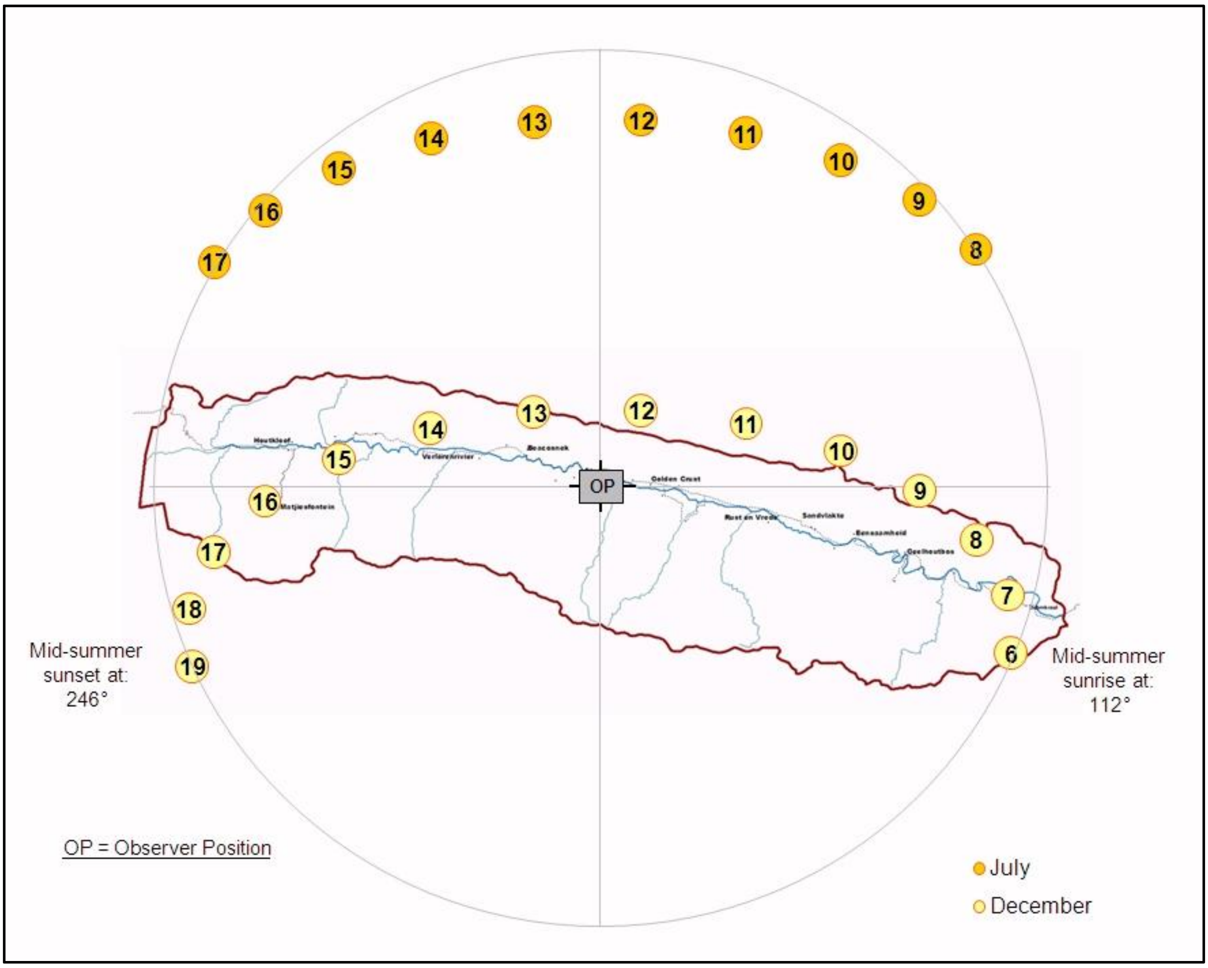


Figure 7: Summer and winter sun trajectories, as observed from Studtis.

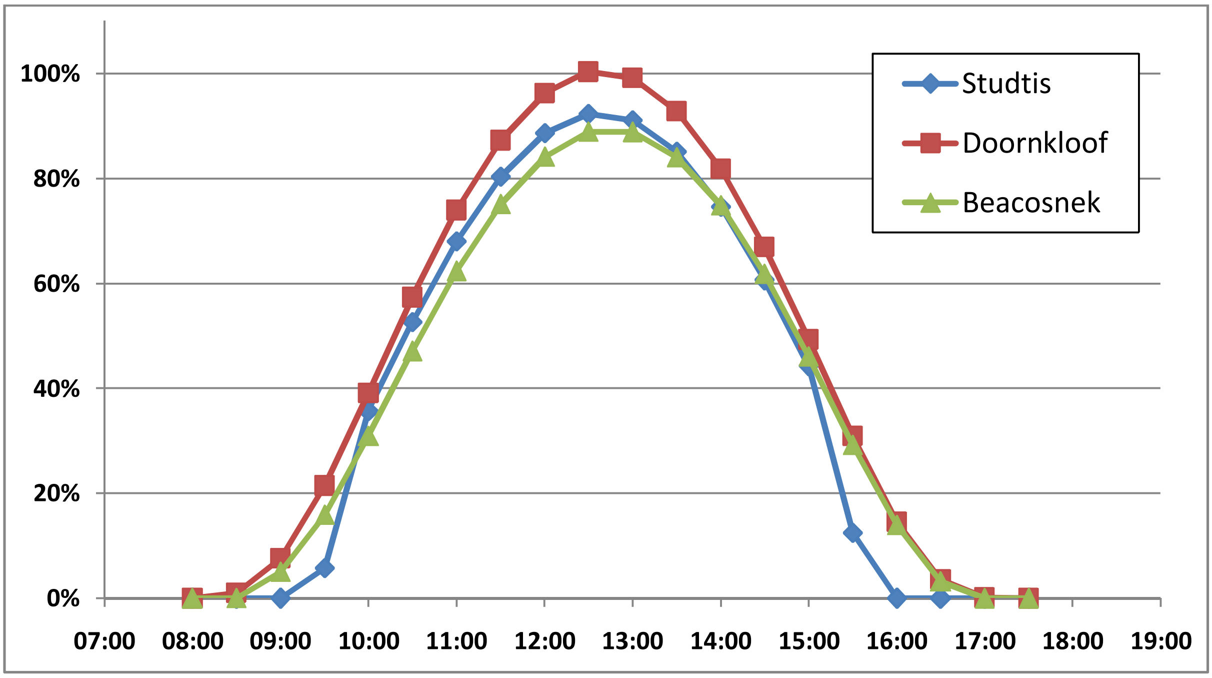


Figure 8: Comparative direct winter solar radiation at three localities in the Baviaanskloof. Doringkloof was chosen as an unobstructed site, while Studtis and Doornkloof have some shadowing effect from the Baviaanskloof Mountain range.

A slope analysis on the DEM in the GIS, provided maps depicting slope steepness, slope form, aspect and terrain units, as shown in the figures below.

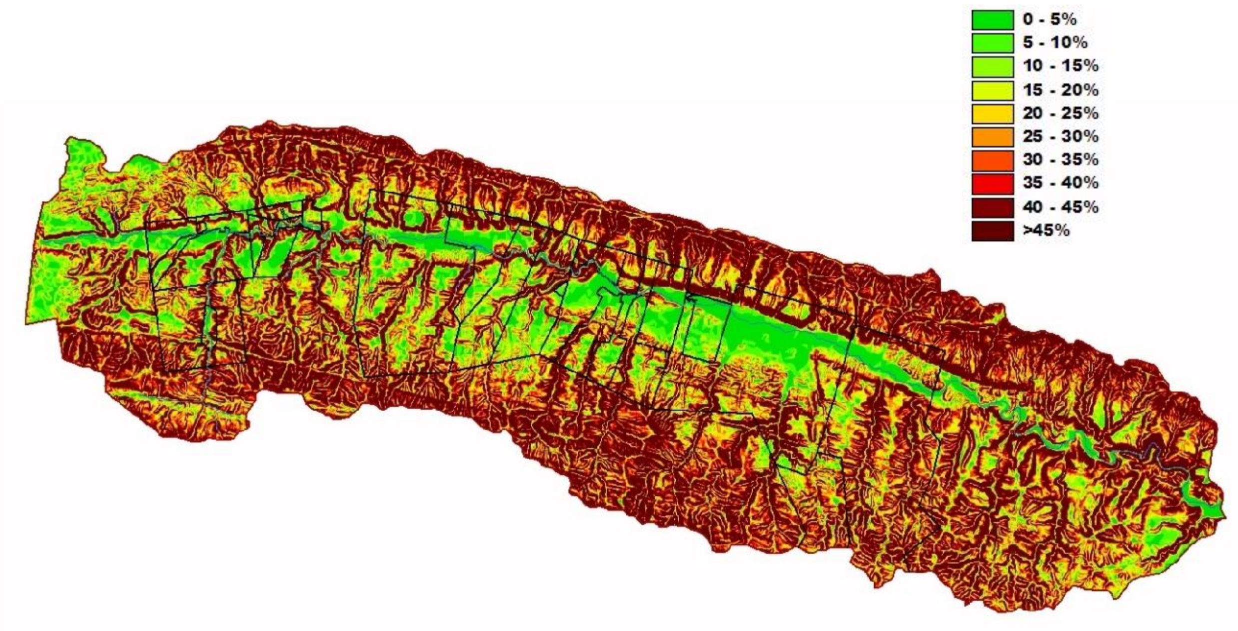


Figure 9: Slope gradients. All the cultivated activities are on the flat valley floor (green).

The slope form indicates whether the land surface is convex (beige) or concave (blue). Surface water will tend to accumulate in concave areas.

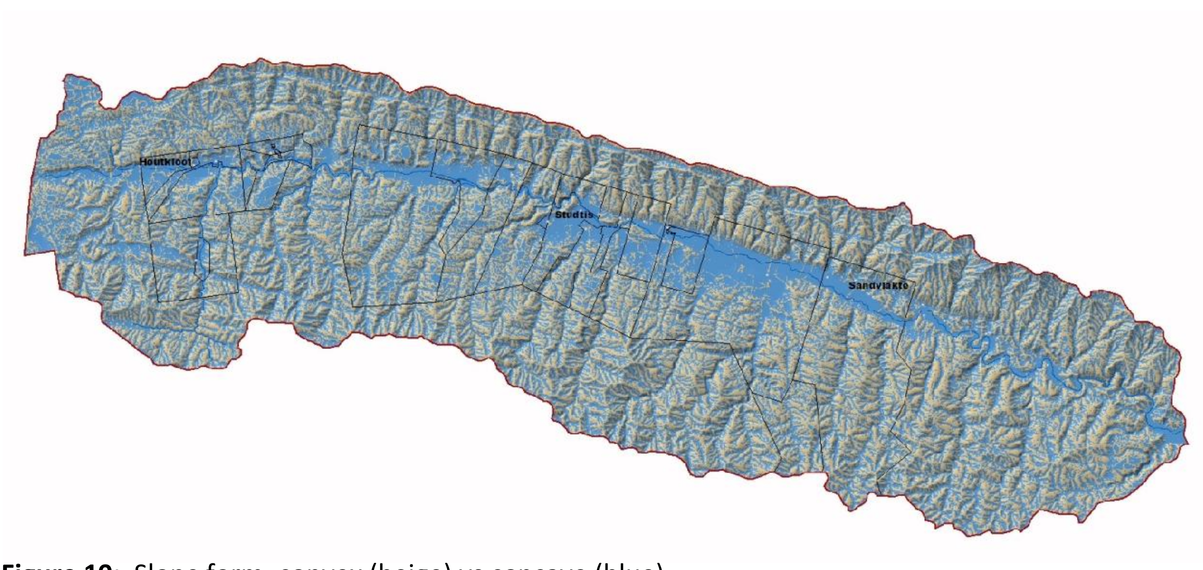


Figure 10: Slope form, convex (beige) vs concave (blue).

The aspect map indicates the direction in which a slope is facing. The predominantly north facing slopes (red) south of the Baviaanskloof River, is clearly visible in Figure 11.

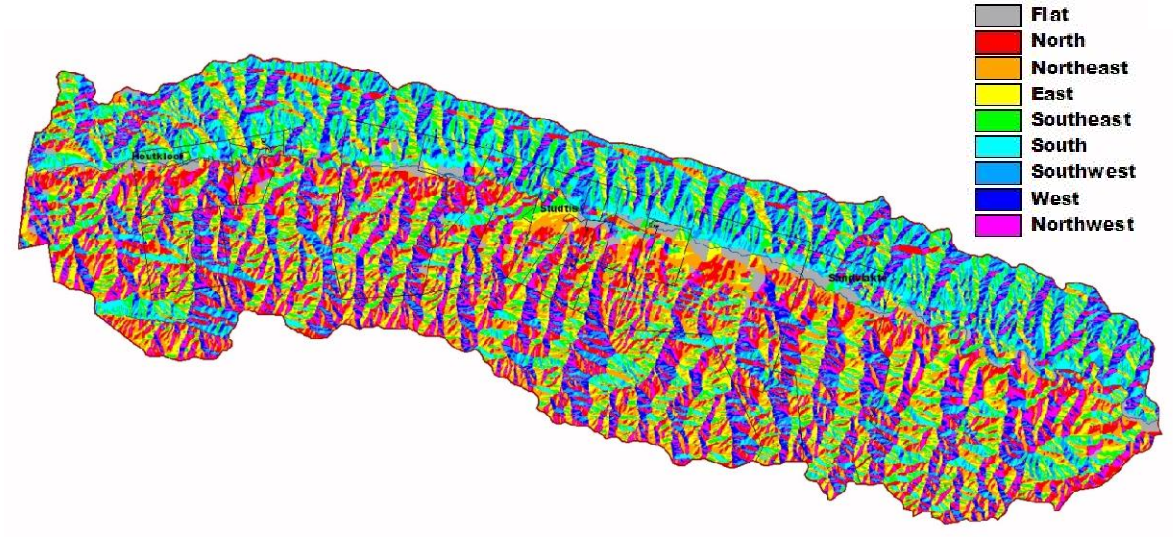


Figure 11: Aspects (slope direction).

The terrain unit map indicates terrain positions, i.e. crest, midsole, foot slope and bottom slopes.

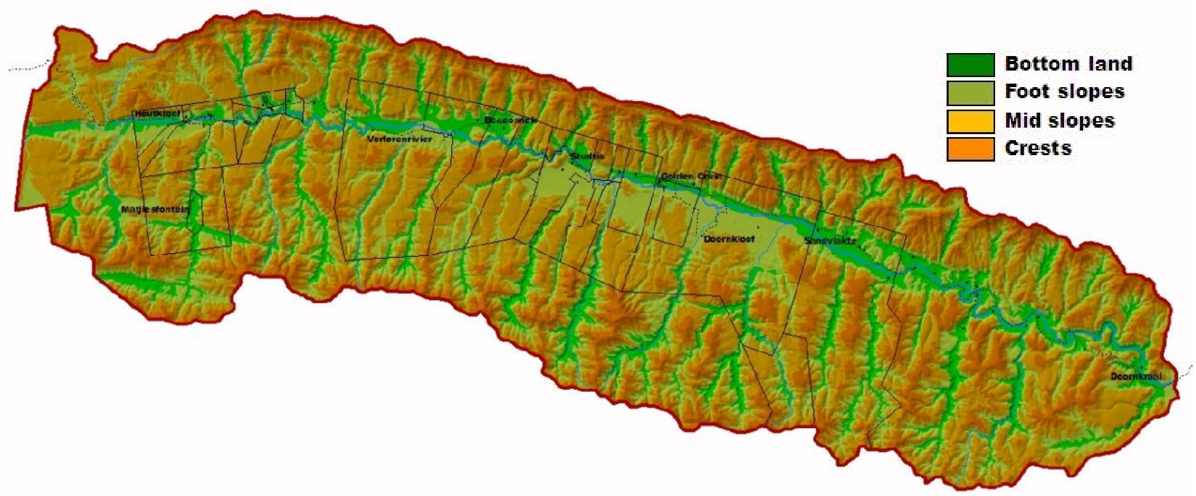


Figure 12: Topographic classification of the landscape into crests, mid slopes, foot slopes and bottom slopes.

8. Climate

The most comprehensive climate dataset obtained for this study is for the Baviaanskloof-1, weather station, managed by ARC's Agromet division of the Institute for Soils, Climate and Water and made available through AGIS. Rainfall was or is also being recorded at a number of stations by Agromet or the South African Weather Service. Additional data used in this study, included the data presented by the South African Atlas for Climatology and Agrohydrology (Schulze, 2007) and the Water Research Commission (Lynch, 2004). A detailed monthly summary of the Baviaanskloof 1 data is presented in the appendix.

8.1 Rainfall

At a macro scale, the study area is situated in an inland valley, cut off by two mountain ranges from the Indian Ocean. The resulting climate is continental and drier than the coastal region. The high mountain ranges do however create a catchment that drains towards the centre of the valley, thereby creating a wetter environment than suggested by the rainfall alone. The rainfall is classified as non-seasonal, but the distribution between winter and summer rainfall, as recorded at the Baviaanskloof-1 station of the last 27 years indicates that 69% of the rainfall occurs during summer (Oct-Mar). The rainfall distribution map below, was derived from the dataset of the South African Atlas of Climatology and Agrohydrology (Schulze, 2007).

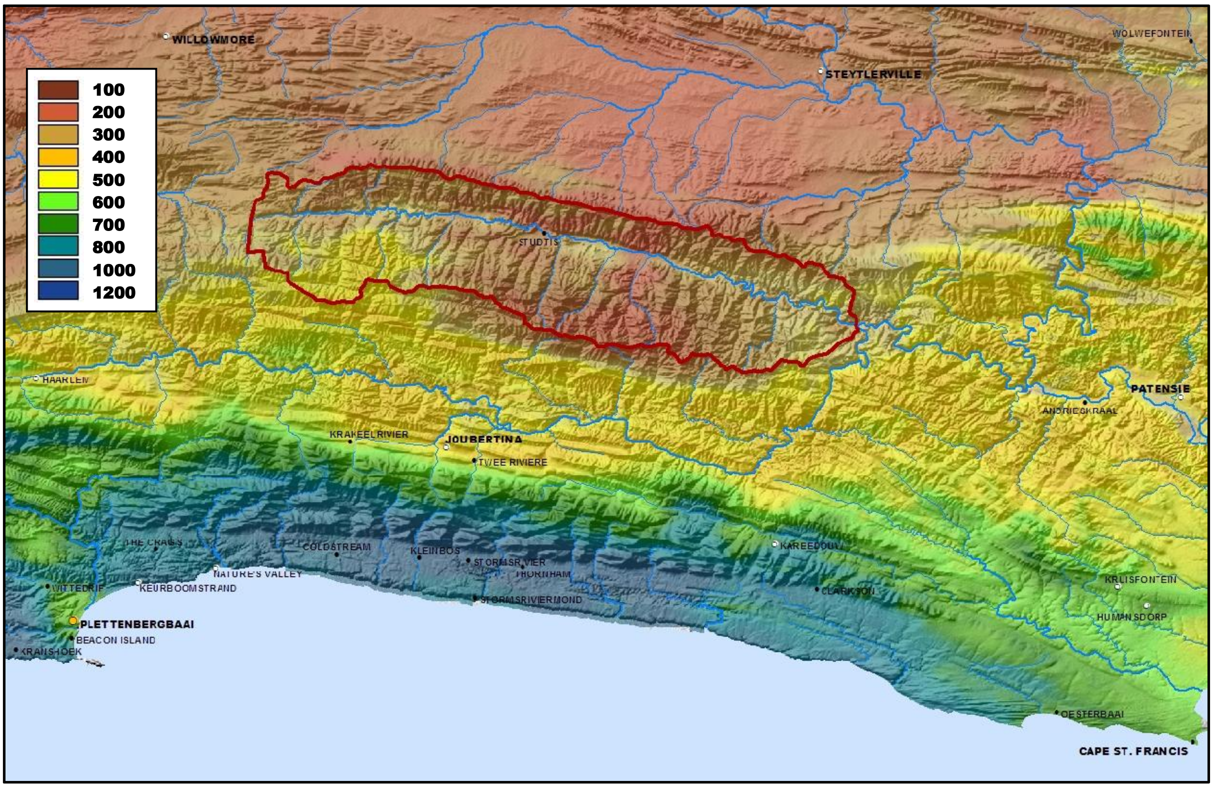


Figure 13: Spatial distribution of annual rainfall in the Baviaanskloof and surrounding area.

Table 2 below, reports the long term average rainfall as recorded at a number of rain gauges along the length of the valley.

Table 2: A summary of rainfall as measured at six localities in the Baviaanskloof.

Station	Period	Altitude[1]	Min	Max	Average
Nuwekloof[2]	1877-2000	794	194	572	314
Studtis Bos	1900-2000	508	74	686	236
Studtis Pol	1993-2011	460	46	468	281
Baviaanskloof 1	1985-2012	450	121	466	283
Rust en Vrede	1877-2000	420	47	573	219
Zandvlakte	1900-2000	380	96	550	275

[1] Altitude derived from DEM
[2] Only 6 years of data available

No significant trend between altitude and rainfall could be identified, especially when keeping in mind that the highest station, which also has the highest mean rainfall, has a short rainfall record of only 6 years. The absence of a clear spatial trend in rainfall is confirmed by the spatial summer rainfall map shown below, although the rainfall in the mountain ranges south of the Studtis – Zandvlakte area, appears slightly lower.

Figure 14: Spatial distribution of summer rainfall in the Baviaanskloof area (Schulze, 2007).

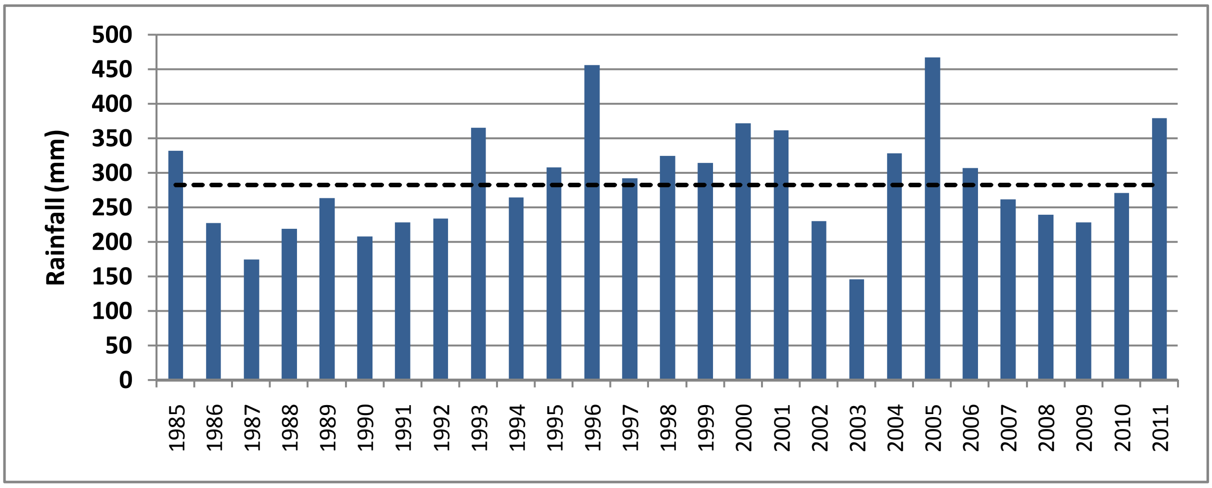


Figure 15: Rainfall as measured at Baviaanskloof-1, since 1985.

Figure 15 shows that a number of consecutive years with below average rainfall can occur (1986-1992; 2007-2010). During these dry periods, the groundwater resource may be stressed when abstraction for irrigation remains at normal levels and total failure of water sources has occurred in some places in the valley. The risk of drought is thus very real and for this reason, the large scale planting of drought sensitive perennial crops is not recommended and probably has shown to be unfeasible in the past. Drought tolerant crops (olives, jojoba) often are able to survive dry periods, but at much lower yields, again undermining the viability of perennial crops.

8.2 Evaporation

Evaporation is influenced by rainfall, humidity, wind and temperature and was traditionally measured in an American Class-A evaporation pan, which was troublesome to properly maintain and keep record of. With the advent of new electronic weather stations evaporation is calculated by using the Pennman-Monteith or FAO-Pennman equation. This information also forms the basis for the estimation of crop water requirement and thus irrigation requirement.

The annual evaporation at Baviaanskloof-1 is 1694 mm and is almost 6 times higher than the rainfall. The calculated Aridity Index – a measure of the shortfall between summer rain and the general water requirement of plants – amounts to 308 mm. Figure 16 plots the evaporation against rainfall and effective rainfall (also see paragraph 7.3).

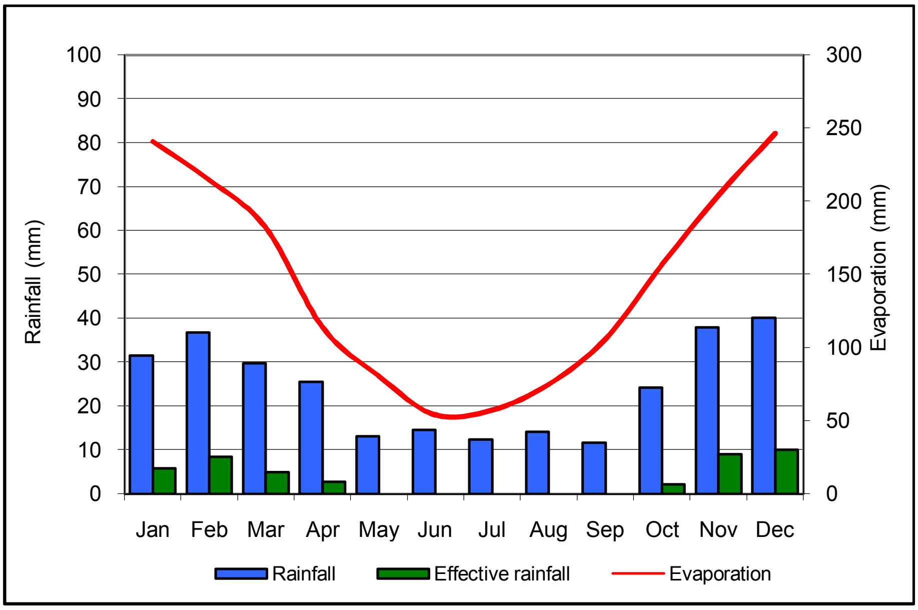


Figure 16: Mean monthly rainfall and evaporation as measured at Baviaanskloof-1.

The WRC-data (Schulze, 2007) does not indicate any significant spatial trend in evaporation within the Baviaanskloof, but indicates a value of ±2100 mm/a – approximately 400 mm higher than presented by the Baviaanskloof-1 data.

8.3 Temperature

Despite the uniform trend in rainfall and presumably also evaporation across the valley, other climate parameters are expected to vary more significantly. The variability in solar radiation due to shadow effects of the mountain ranges has already been demonstrated above. Temperature and temperature related parameters, such as frost and winter chill accumulation will change with altitude. Some of these parameters are being measured at the Baviaanskloof-1 station, but the WRC data (Schulze, 2007) was used to extrapolate to the rest of the valley.

Where sufficient water is available, the impact of low rainfall on crop production can be overcome by irrigation. Under these conditions, the temperature becomes the main climatic parameter determining climate suitability for crop production. Within limits, warm temperatures are inducive to vigorous growth and higher yields, but excessive temperature can impact negatively on quality of sensitive crops. Other crops may require high winter chill (e.g. most pomefruit varieties), whilst early or late frost can be fatal.

According to the Baviaanskloof-1 station, the warmest months are January and February with average maximum temperatures of 30.5°C and 30.6°C respectively, while highest average monthly maximum temperature recorded since 1985 is only 32.5°C. The coldest months are June and July with average minimum temperatures of 5.9°C and 5.3 °C. The lowest recorded average monthly minimum is 3.4°C.

The temperature regime of the Baviaanskloof was compared to other similar regions through a process of matching the rate of accumulation of heat units from spring to fall, with other known areas (listed in Table 3). As perhaps expected, the early (spring) conditions in the Baviaanskloof closely match those of Addo, with Paarl, Worcester and Robertson being cooler and Pretoria and Hazyview warmer. Later during the summer season, the Baviaanskloof is marginally warmer than Addo and Hazyview with Worcester (Aan-de-Doorns) becoming a close match. Joubertina, as an indicator of the adjacent Langkloof directly south of the Baviaanskloof, is however much cooler throughout summer.

Table 3: A summary of Heat Units as calculated from data measured at six localities in SA.

Locality	Heat Units (GDD) accumulated from Sep – Mar (base 10°C)
Joubertina	1726
Worcester (Aan-de-Doorns)	2187
Addo	2216
Baviaanskloof	**2285**
Pretoria (Plant Institute)	2298
Paarl (Nederburg)	2360
Hazyview	2492

The WRC-data (Schulze, 2007) do indicate some spatial variation in temperature data, highly correlated with altitude, as shown in Figures 17 and 18.

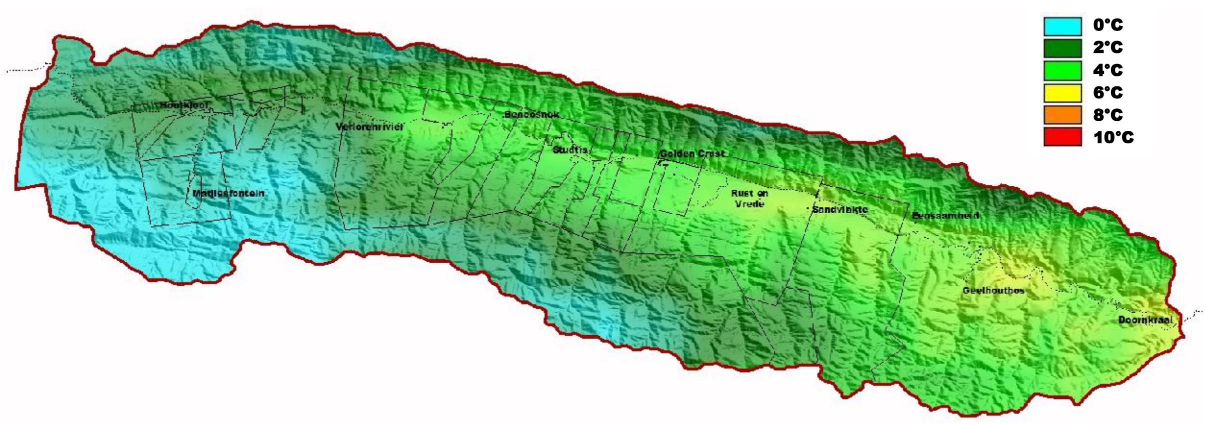


Figure 17: Spatial distribution of July minimum temperature in the Baviaanskloof area, with Matjiesfontein the coldest and Studtis the warmest.

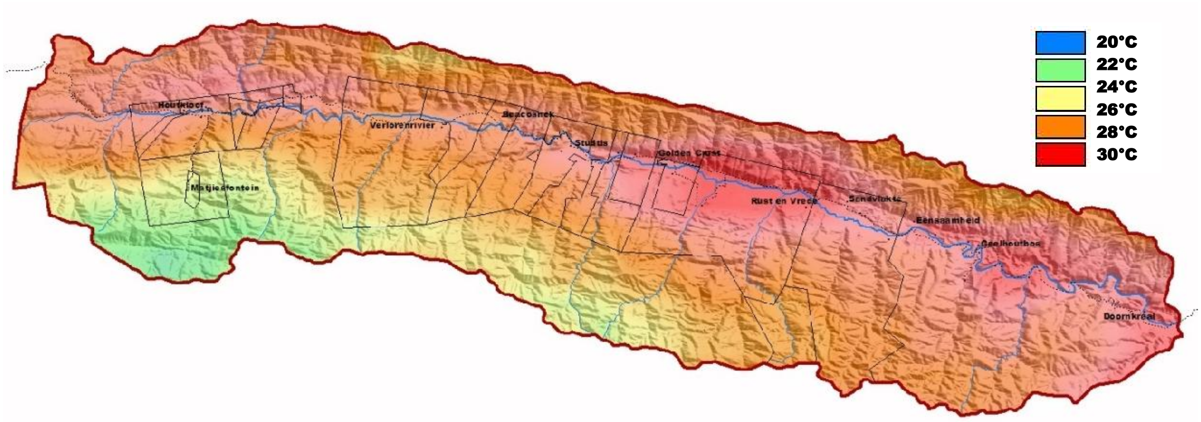


Figure 18: Spatial distribution of February maximum temperature in the Baviaanskloof area, with again Matjiesfontein the coolest and Golden Crust – Rust-en-Vrede the warmest.

Although the lowest recorded average monthly temperature since 1985 is 3.4°C, temperatures at or near 0°C do occur and frost is common in most parts of the valley. More frequent and severe frost was also confirmed by the farmers in the western (higher) part of the valley, during the interviews. The Sewefontein farm has been indicated as a frost free area, supposedly due to the micro relief and a "drainage" of cold morning air off the farm. One of the farmers in the eastern (lower) part of the valley has indicated, as a general remark, that the intensity of frost is lately lower than in the past.

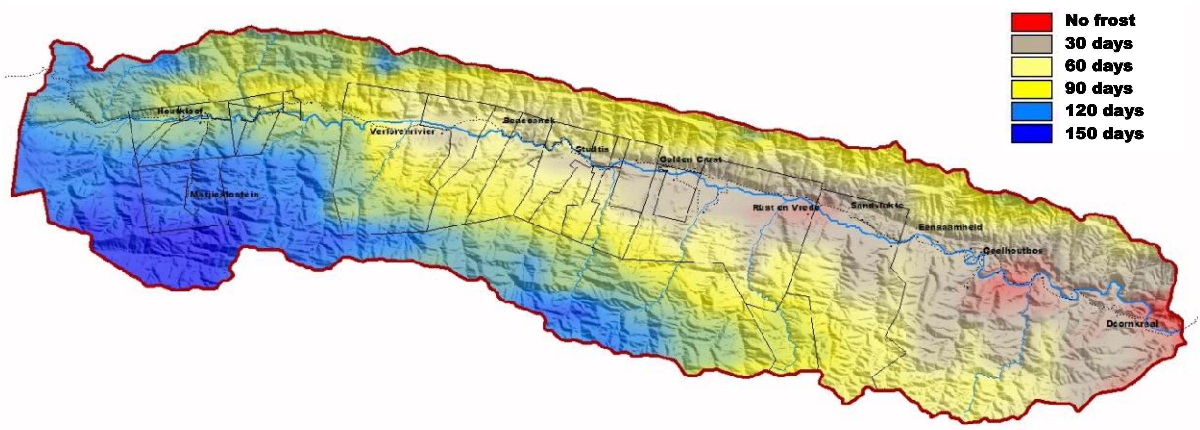


Figure 19: The frost duration map, indicates a longer period with possible frost at the higher parts of the valley (blue) and shorter duration (beige to red) at Rust-en-Vrede.

8.4 Chill accumulation

Some perennial plants (or seeds) require exposure to low temperatures (vernalisation) to ensure good flowering or budburst and subsequent good yields. This is often referred to as the chill requirement of a crop. The threshold temperatures can differ between crop types, while certain varieties of the same crop can be more or less sensitive to vernalisation. A number of chill accumulation calculation methods have also been developed by research institutes around the world, complicating the comparison of calculated values. As chill unit accumulation (calculated from hourly temperature values) has not been reported by the Baviaanskloof-1 station, the modified Richardson chill units or PCU (Positive Chill Units) in the WRC-data (Schulze et al, 2007) were used as an indicator of chill accumulation and its spatial distribution in the Baviaanskloof (Figure 20). This data indicates chill accumulation values for the Baviaanskloof, as listed in Table 4:

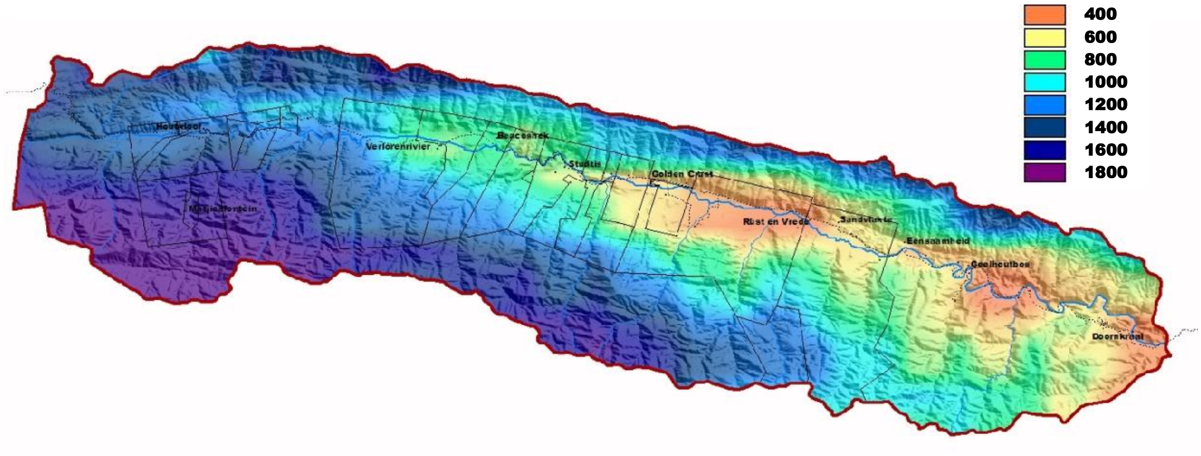


Figure 20: Spatial distribution of positive chill unit accumulation in the Baviaanskloof area. The lower accumulation (Rust-en-Vrede) is again linked to the lower altitudes.

Table 4: Chill unit accumulation in the Baviaanskloof.

Locality	Positive Chill Units
Sandvlakte	560
Rust-en-Vrede	390
Studtis	600
Beacosnek	820
Houtkloof	1200
Matjiesfontein	1700

8.5 Wind

The average annual wind run is moderately high at 6.1 km/h, with the highest wind incidence during the summer months when average monthly wind speeds of 7.4 km/h occur. The highest average monthly wind speed of 10.3 km/h was recorded in January 1987. As these figures reflect monthly mean values, wind speeds during storm events can be expected to reach much higher figures.

8.6 Humidity

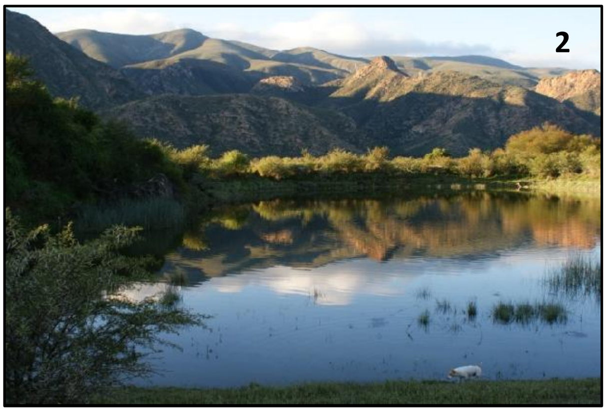
Average maximum humidity reaches 75% to 80% throughout the year. Minimum humidity is the lowest during winter (21%) and only marginally higher in summer (24%).

9. Water

9.1 Water Sources

In general, the Baviaanskloof appears less arid than what the low rainfall would suggest. Three main water sources can be identified, namely the (i) surface flow in the Baviaans River and its tributaries, (ii) the Table Mountain Group (TMG) fractured aquifer and (iii) the Alluvial aquifer. The TMG aquifer refers to the water movement in the fractures and joints of the mountainous areas of the TMG where the groundwater recharge is estimated at 6 – 15 mm/a. The Alluvial aquifer is situated along (under) the Baviaanskloof River, varying in thickness from a few meters at the sides to >50 m in some of the central positions. Conglomerates, pebbles and alluvial deposits of the TMG sandstones, Bokkeveld shales and Enon conglomerates form the conducting material of the Alluvial aquifer. The net average groundwater recharge of the Alluvial aquifer is in the order of 25-40 mm per year. Interconnectivity between the two aquifers is uncertain, but possible (Jansen, 2008).

This study did not include any survey or assessment of the water resource, other than water sampling at 8 locations, for laboratory analysis. With a few exceptions (boreholes into the TMG aquifer), the Alluvial aquifer is used for irrigation. On many farms, the source – either is spring or an excavation or sump (**1**) into the aquifer – is located one or two farms upstream from where the water is channeled to elevated holding dams (**2**), providing some water head (pressure) to allow irrigation under gravity, thereby eliminating or reducing the need to pump the water.



At each sampling location, water was taken from the same source as that used for irrigation. Sample 8 is used for domestic purposes and was also analysed for nitrate. Figure 21 indicates the sampling localities.

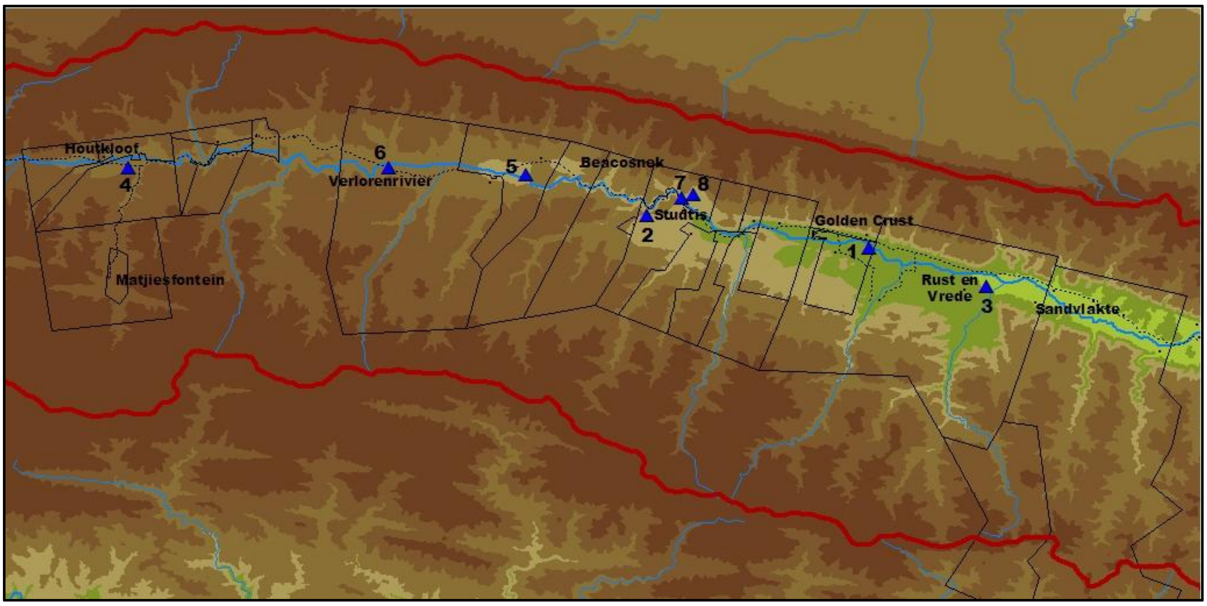


Figure 21: Water sampling points.

An extraordinary case is the artesian borehole (**3**) into the TMG aquifer, at Sewefontein, of which the latter are purportedly flowing constantly since 1937.

9.2 Water Quality

With the geology of the catchment being predominantly sandstone of the Table Mountain Group, the salt content of the waters of the Baviaanskloof is generally low and thus favourable to be used as irrigation water. Local contact with more saline sediments (shale) can however lead to lower water quality.

A laboratory analysis of the water samples resulted in the figures as presented in Table 5, below.

The analysed irrigation water quality is mostly very good, in terms of its overall salinity and salt concentrations. It is however corrosive and will erode metal and even fiber cement pipelines. The use of PVC pipes, retro-fitted onto centre pivot systems is therefore common practice. The less optimal SAR levels refer to the potential dispersing of clay particles when irrigated with these waters, thereby inducing infiltration problems. As most of the top-soils are sandy, severely restricted infiltration is not expected, but some less serious surface crusting has been observed, which may relate to the relatively high SAR at this low total salt contents. This phenomenon can be easily rectified through gypsum application, when needed.

The clogging of drip emitters due to iron or scaling is not expected.

Table 5: Water quality analysis data. Elements critical to irrigation water quality are colour coded.

Element/ Parameter	Unit	Sample Nr [Locality as per map in Figure 20]							
		BAV1	BAV2	BAV3	BAV4	BAV5	BAV6	BAV7	BAV8
pH		7.0	5.5	6.8	6.9	6.9	7.2	6.6	6.6
Conductivity	mS/m	26	9	25	9	8	13	17	13
TDS	mg/l	169	59	163	59	52	85	111	85
Calcium	mg/l	10	3	9	3	3	5	5	5
Magnesium	mg/l	7	3	6	3	3	3	4	3
Potassium	mg/l	3	1	3	1	1	2	2	4
Sodium	mg/l	34	10	34	10	10	17	24	16
Chloride	mg/l	56.8	21.3	53.25	21.3	21.3	31.95	35.5	24.85
Sulphate	mg/l	17	7	18	6	3	6	9	3
Bicarbonate	mg/l	40	10	40	10	10	20	30	30
Cations	meq/l	2.63	0.86	2.5	0.87	0.86	1.31	1.68	1.30
Anions	meq/l	2.61	0.91	2.53	0.89	0.83	1.35	1.68	1.26
Copper	mg/l	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02
Iron	mg/l	0.04	0.02	0.03	0.28	0.02	0.39	0.07	0.05
Alkalinity	mg/l	40	10	40	10	10	20	30	30
Hardness	mg/l	54	20	47	20	20	25	29	25
SAR		2.02	0.98	2.15	0.98	0.98	1.48	1.94	1.40
Corrosivity Index		2.45	3.74	2.35	3.63	3.32	2.57	1.98	1.27
Langelier Index		-1.81	-4.3	-2.05	-2.98	-2.98	-2.18	-2.61	-2.60
Aggressiveness Index		10	7.4	9.8	8.8	8.8	9.6	9.2	9.2
Rayznar Index		10.6	14.3	10.9	12.9	12.9	11.6	11.8	11.8
Nitrate	mg/l								<3.0

Explanation of colour coding.

GOOD	USEABLE	ONLY USABLE WITH SPECIAL PRECAUTION	ONLY USABLE UNDER SPECIAL CONDITIONS	MOSTLY NOT USABLE

9.3 Irrigation requirement

The Baviaanskloof has an average annual rainfall of 292 mm of which 200 mm can be expected during the summer and 92 mm during winter. Only a small fraction of this rainfall is considered to be effective, as some water will end up as runoff, some will evaporate and some may percolate out of the root zone (recharging the aquifer) and is therefore also not available to plants. The effective annual rainfall is calculated as only 43 mm, while the evaporation is 1150 mm in summer and 544 mm in winter.

These figures can be used to calculate the theoretical water requirement of a crop, making use of crop co-efficients or crop factors that relate the water use to evaporation. As an example, the crop water requirement of maize, planted in late September, can be calculated as follows:

Table 6: Calculation of maize Potential Evapo-Transpiration (PET_{crop}), soil water balance and crop water deficit.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total /Ave
Rain (mm)	32	37	30	25	13	15	12	14	12	24	38	40	292
Effective Rain (mm)	6	8	5	3	0	0	0	0	0	2	9	10	43
Reference ET_0 (mm)	228	178	151	102	87	69	74	92	120	159	200	235	1694
Crop Factor	0.55	0.4	0	0	0	0	0	0	0	0.25	0.45	0.55	
Crop PET_c (mm)	125	71	0	0	0	0	0	0	0	40	90	129	455
Crop PET_c – Eff. Rainfall (mm)	**120**	**63**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**38**	**81**	**119**	**420**
Surplus Rainfall (mm)	*0*	*0*	*5*	*3*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*8*

In this example it is calculated that maize will use 455 mm of water, of which only 35 mm will be supplied by rainfall and 420 mm needs to be supplied by irrigation. Similarly the water deficit (irrigation requirement) of winter grown wheat is calculated at 217 mm. It is thus clear that dry land (rain fed) crop production is not a possibility in the Baviaanskloof.

Based on the calculation procedure of table 6, the water requirement of a number of crops has been calculated as shown below (Table 7).

The agricultural water use (irrigation) in the Baviaanskloof has been estimated at 1.75m m^3/a (Jansen, 2008) and 2m m^3/a (DWA, 2004). The estimate of Jansen (2008) was based on an irrigated area of 500 ha, an average water requirement of 200 mm per crop, 1.5 growing season per year and irrigation losses of 5 – 15%. Given the total cultivated area of 740 ha (Table 1) and assuming 33% are fallow lands (thus 490 ha irrigated) and an average irrigation requirement of 670 mm/a – calculated from the water requirement figures for a crop composition of equal areas maize + wheat & vegetable seed – it is proposed that the total annual water requirement for irrigation in the Baviaanskloof is closer to 3.3m m^3/a (3 284 000 m^3).

Maize, followed by wheat: 5600 m^3/ha/a + 2889 m^3/ha/a = 8489 m^3/ha/a
Vegetable Seed: 4916 m^3/ha/a
Average: 6702 m^3/ha/a
Estimated total volume of water used for irrigation: 6700 m^3/ha/a x 490 ha = **3.3m m^3/a**

In terms of the legality of this estimated use, being 1.2m m^3 more than the volume estimated by DWA, it is worth putting this figure into perspective. The General Authorisations in terms of section 39 of the National Water Act, 1998 (Act no. 36 of 1998), as published in the Government Gazette No 399 of March 2004, allows for groundwater abstraction of 400 m^3/ha/a in the quaternary catchments L81A-D – being the Baviaanskloof catchment. The total farm area in the Baviaanskloof is 40 800 ha, thus allowing an annual abstraction of 400 m^3/ha/a x 40 800 ha = 16.3 m m^3 or almost 5 times the estimated water use, under the General Authorisation. The total annual recharge of all four quaternary catchments (L81A-D), calculated at the minimum recharge rate of only 15 mm per annum, amounts to 18.3 m m^3 over the catchment area of 121 725 ha. The estimated irrigation water abstraction of 3.3 m m^3/a is therefore considered both sustainable and legal, provided that all uses are duly registered. In terms of sustainability however, this statement is only true if the TMG and Alluvial aquifers are well connected. In an attempt to differentiate between the two catchments, a GIS analyses procedure was used to delineate the catchment area of only the Alluvial aquifer above Farm 21 – the farm furthest downstream (Figure 22). An area of 31 590 ha was obtained. At a recharge rate of 25 mm/a (25-40 mm/a was reported by Jansen, 2008), the annual recharge is estimated at 7.9m m^3 or 2.4 times the estimated annual abstraction. The estimated abstraction for irrigation would therefore still be considered sustainable, even without connection between the two aquifers.

Table 7: Calculated irrigation requirements of a number of key crops.

		Irrigation Requirement					
		Total Req. - Eff. Rain		Peak requirement (m^3/ha/week)			
Crop	AIS[A]	mm/a[B]	m^3/ha[C]	Crop Req.[B]	Drip	Micro	Sprinkler
Annuals							
Vegetable Seed	Sprinkler	369	4916	295	328	369	394
Maize	Sprinkler	420	5600	270	300	338	360
Wheat	Sprinkler	217	2889	134	149	168	179
Tobacco	Sprinkler	509	6785	450	500	563	600
Potatoes	Sprinkler	297	3959	237	264	297	316
Tomato/Peppers	Sprinkler	605	8065	348	387	435	464
Dry Bean Seed	Sprinkler	399	5314	348	387	435	464
Perennials							
Lucerne	Sprinkler	889	11851	270	300	338	360
Olives	Drip	550	6111	167	186	209	223
Decid. Fruit[EARLY]	Micro	613	7661	270	300	338	360
Pecan Nuts	Drip	613	6810	270	300	338	360
Figs	Drip	295	3273	141	157	177	189
Pomegrantes	Drip	632	7025	244	272	305	326
Wine Grapes	Drip	338	3754	116	129	145	154
Arid Zone Crops	Drip	338	3754	116	129	145	154

A AIS = Assumed Irrigation System
B Crop requirement without allowance for irrigation system inefficiency
C Crop requirement under assumed irrigation system

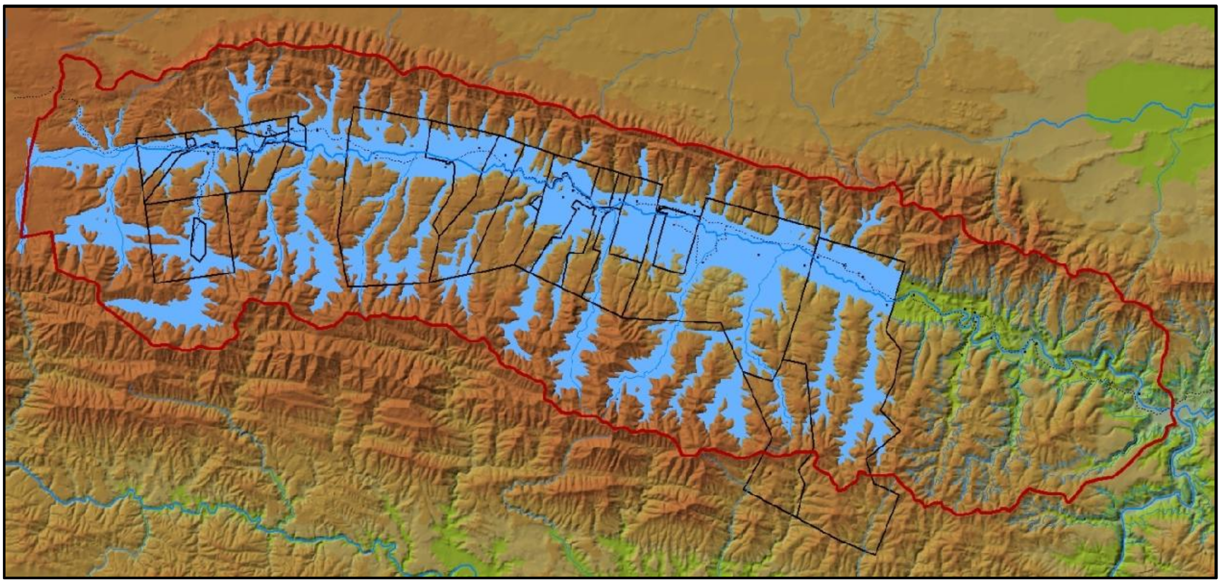


Figure 22: Estimation of the catchment area of the Alluvial aquifer down to Sandvlakte, the lowest lying farm, making use of a supervised GIS delineation procedure.

10. Soils

The geology of the Baviaanskloof is dominated by formations of the Table Mountain Group. The mountain ranges are mostly quartzitic sandstone, with feldspathic sandstone, shale and Enon conglomerates mainly on the foot hills south of the Baviaanskloof River. With very few exceptions, all cultivated fields are on the alluvial deposits associated with the floodplain and river banks of the Baviaanskloof river and some larger tributaries (Geoscience, 1990).

10.1 Soil survey

The soil survey conducted during the field visit, can at best be described as a brief reconnaissance of the soil types of the floodplain. The survey was done over a period of four days and due to logistical arrangements, could not be conducted in a continuous trajectory along the length of the valley, resulting in a haphazard numbering sequence of profile pits. Farmers assisted in preparing profile pits on their fields. The request was for one profile located in a field near to the Baviaanskloof River and another in a the field furthest from the river. In a number of places river cuttings, erosion dongas, pipe trenches and hand auger drillings were used to gain additional soil information.

Most profile pits and a few auger drillings, were sampled at two depths for chemical laboratory analysis as well as sand, silt and clay determination (Laboratory reports attached in appendix).

The soils where classified according to Soil Classification: A Taxonomic System for South Africa (Soil Classification Working Group, 1991) and an appraisal of the soil potential for agricultural purposes was made. The positions of the profile pits and other observation points were surveyed by GPS, while exposed profiles were also photographed for future reference (p. 29 – 31). The initial aim of the profile pit placement was to focus on the cultivated areas and to have pit positions over the full altitude gradient. This was largely achieved, although logistical constraints prevented Matjiesfontein from being included in the survey (Figure 23).

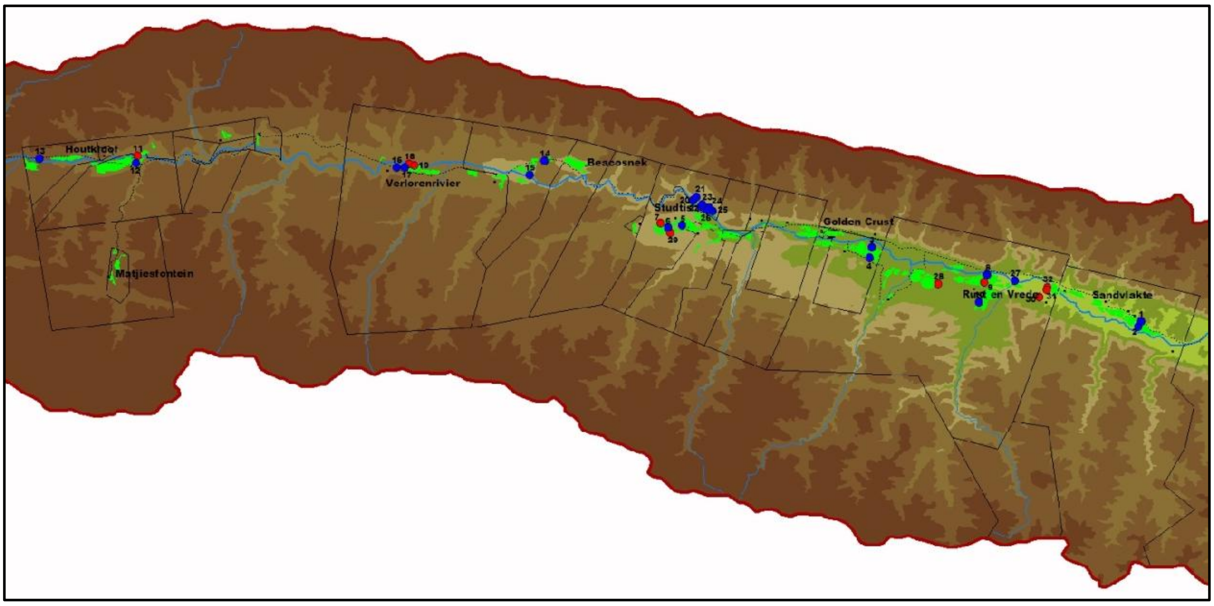


Figure 23: Distribution of profile pits assessed during reconnaissance survey. Blue dots are sampled profiles. Cultivated fields are indicated in bright green (also see A3 map in appendix).

Due to the limited number of observations a soil map cannot be compiled. The main physical properties of each profile are however summarised in Table 10. Table 8 below provides a description of the modal profiles of each of the soil types encountered in the survey.

Table 8: Soil descriptions of modal profiles.

Soil Form	Profiles	Description
Hutton	13; 14;20;30	A: 30cm, dark brown to reddish brown; me SaLm; apedal, moderately soft, rapidly permeable, gradual undulating transition to B: 70-90cm, reddish brown to strong reddish brown, me SaLm; apedal, soft to moderately soft; rapid to moderately permeable, free lime nodules; 10 – 20% fi gravel, gradual undulating transition to mostly weathering shale
Clovelley	5; 21; 24	A: 30cm, dark brown, fi SaClLm, apedal soft, moderate to tapid permeability, gradual undulating transition to B: 80-120 cm, dark yellow brown to yellow brown, fi Sa to SaLm, apedal, soft to moderately hard, moderate to rapid permeability, up to 30% fi gravel in stone layer
Oakleaf	3; 6; 7; 16; 28	A: 15-30cm, brown to dark brown, me-fi SaLm –LmSa, apedal, soft to moderately hard, rapid to moderate permeability, gradual transition to B: 100-120 cm, pale brown to pale yellow brown, fi SaLm-LmSa, neocutanic, soft to moderately hard, rapid to moderate permeability, free lime in some profiles
Tukulu	4	A: 30cm, dark brown, fi SaLm, apedal, moderately hard, moderate permeability, gradual undulating transition to B1: 90cm, very pale brown, fi SaLm, neocutanic, hard, moderately permeable, few faint geogenetic mottles, gradual undualting transition to B2: 120+cm, very pale brown, fi SaLm, soft plinthic, hard, moderate slow permeability, many distinct redox mottling
Swartland	10	A: 30cm dark brown, fi LmSa, apedal, soft moderate permeability, distinct undulating transition to B1: 40cm, pale brown, fi SaLm, pedokutanic, moderately hard to hard, moderately permeable, few faint geogenetic motles, distinct undulating transition to B2: 120+cm, strong reddish brown, fiSaLm, peducutanic, moderately hard, moderately permeable, few faint geogenetic mottles
Dundee 1	8;9;29	[Dundee soils representative of the lower floodplain - wetland character in places] A: 30cm, dark brown, fi Sa – SaLm, apedal, soft, rapid permeability, abrupt transition to B1: 50-60cm, very dark brown, fi SaLm, apedal, soft, moderate to slow permeability, many distinct redox mottling, abrupt transition to B2: 80cm, grey, fi SaLm, apedal, soft, moderate to slow permeability, many distinct redox mottling, abrupt transition to B3: 110 cm, white, fi SaLm, apedal, soft, moderate to slow permeability, many distinct redox mottling, abrupt transition to B4: 140cm, dark grey, fi SaLm, apedal, soft, rapid to moderate permeability, many distinct redox mottling in root canals, abrupt transition to B5: 160 cm, white, fi Sa
Dundee 2	1;2;11;12; 15;16;17;18 19;22;23;25 26;27;31;32	[Dundee soils representative of alluvial deposits – no distinct wetland character] A: 20cm, dark brown, me SaLm, apedal, soft, rapid permeability, gradual undulating transition to B: 140+cm, pale brown to light reddish brown, fi-co LmSa – SaLm, alternating layers of loam, sand gravel and stone deposits, soft to moderately hard, mostly moderately to rapidly permeable, often transitions to fine river bed gravel.

The main soil limitations observed during this study are:

- Layering associated with the alluvial soils of the Dundee soil form;
- Low water retention capacity due to high gravel/stone content or low clay content
- High erodibility
- Compaction and or hard setting

A potential rating was assigned to each profile in terms of the soil's suitability for (a) annual crops and (b) perennial crops, both under irrigation. Dry land cultivation was not considered as this practice under the low rainfall of the Baviaanskloof is not considered viable. The following interpretation can be used in conjunction with the potential ratings:

Table 9: Interpretation of soil potential ratings

Rating	Potential	Suitability
<2.0	Very Low	Not suitable
2.1 – 3.0	Low	
3.1 – 4.0	Low-Medium	Marginal
4.1 – 5.0	Medium	Conditionally recommended
5.1 – 6.0	Medium-High	Recommended
>6.0	High	Highly suitable

Table 10: Dominant soil properties of each profile pit.

Profile Pit	Soil Form	Effective depth (cm)	Texture of B-hor	Stone % of B-hor	Wetness	Soil Potential	
						Irrig. annual[a]	Irrig. perennial[b]
1	Du	80	LmSa	-	3-6	5.0	7.0
2	Du	90	Sa	f1	3	6.0	7.0
3	Oa	110	SaLm	-	1	7.0	8.0
4	Tu	120	SaLm	-	3	7.0	8.0
5	Cv	120	SaLm	-	1	7.0	8.0
6	Oa	90	SaLm	g2	1	6.0	7.0
7	Oa	60	SaLm	g2	1	5.0	6.0
8	Du	120	LmSa	-	3-6	6.0	8.0
9	Du	120	LmSa	-	3-6	6.0	8.0
10	Sw	120	Cl	f1	3	5.0	6.0
11	Du	150	Sa	f1g1	-	5.0	6.0
12	Du	150	SaLm	f1	3	6.0	7.0
13	Hu	60	SaLm	f2	1	6.0	7.0
14	Hu	100	SaLm	f1	-	6.0	8.0
15	Du	100	Sa	f1g1	3-6	5.0	6.0
16	OaDu	100	LmSa	-	-	7.0	8.0
17	Du	70	LmSa	f1g1	-	5.0	6.0
18	Du	60	Sa	f1g1	3	5.0	6.0
19	Du	60	LmSa	f1g1	-	6.0	7.0
20	Hu	90	LmSa	f1	3	6.0	7.0
21	Cv	70+	Sa	f1	-	6.0	7.0
22	Du	90	SaLm	f1	3	6.0	7.0
23	Du	60	SaLm	f1g1	-	5.0	6.0
24	Cv	80+	Sa	f1	-	5.0	6.0
25	Du	70+	Sa	f1g1	-	4.0	5.0
26	Du	60+	LmSa	g1	6	5.0	6.0
27	Du	150		f1	-	donga	---
28	Oa	150		-	-	donga	---
29	Du	300		f1	-	donga	---
30	Hu	200		f2g1	-	cutting	---
31	Du	200	Sa	f1g1	1	5.0	6.0
32	Du	200	Sa	f1g1	1	5.0	6.0

a Dryland potential of wheat with 172 mm of rainfall
b Potential of perennial crop under full irrigation with appropriate soil preparation

Sa: Sand SaLm: Sandy loam LmSa: Loamy sand Cl: Clay	f1: 20 – 50% fine gravel f2: 50 – 90% fine gravel g1: 20 – 50% coarse gravel g2: 50 – 90% coarse gravel

Wetness numbering: see below for explanation

Upper boundary of free water (cm)	Wetness Symbol			
0 – 30	6	7	8	9
30 – 70	3	6	7	8
70 – 120	2	3	4	5
>120	1			

0 30 90 180 360

Cumulative number of days with free water

4. Alluvial layering in the soils of the flood plain is clearly visible in some river cuttings. (Profile 11)

5. The dark layer in this river cutting is the result of accumulation of organic matter under wetland conditions. Subsequent lowering of the river bed and probably also the modification to the drainage above the alluvial fan that fed water into this area, has completely dried out the wetland. (Profile 297)

6. Deep red soils, deposited during an earlier era, have been eroded down to the bedrock. Increased runoff, due to overgrazing in the catchment of this side stream, may have contributed. (Profile 28)

7. Active redox mottling is evident in a number of the floodplain soils. (Profile 4).

All profile pits (excluding 31 & 32) were photographed, as shown on the following pages:


Profile 1

Profile 2

Profile 3

Profile 4

Profile 5

Profile 6

Profile 7

Profile 8

Profile 9

Profile 10

Profile 11

Profile 12


Profile 13


Profile 14


Profile 15


Profile 16


Profile 17


Profile 18


Profile 19


Profile 20


Profile 21


Profile 22


Profile 23


Profile 24


Profile 25


Profile 26


Profile 27


Profile 28


Profile 29


Profile 30

10.2 Soil analysis

Soil samples were taken at two depths (0-30 cm and 30-60 cm) from selected profile pits for laboratory analysis to assess the fertility status of the soils. The laboratory results are attached in the appendix.

Table 11: Summary of laboratory analysis

	Depth (cm)	pH	Resistance (ohm)	P Bray II mg/kg	Potassium mg/kg	% C
Median	**0 - 30**	6.3	1020	62	187	0.66
Highest		8.0	5160	191	448	1.31
Lowest		5.1	300	18	47	0.23
Average		6.6	1602	81	199	0.68
SE		0.23	281	12.5	24	0.07
Median	**30 - 60**	6.2	1470	30	74	0.29
Highest		8.3	7080	237	598	1.38
Lowest		3.7	150	7	24	0.09
Average		6.5	1721	54	105	0.45
SE		0.26	338	11.7	26	0.08
The C% of the organic horison at profile 29 – an old wetland area – is 12.25% and was not included in the calculation above. It's pH of 3.4 was also omitted.						

The soils are generally slightly acidic to alkaline, high in phosphorus and potassium and low in organic carbon. Only three profiles with high salinity (low resistance) have been encountered, of which only one (profile 10) may respond poorly to gypsum application as the clay content is high and external drainage low.

11. Grazing capacity

No survey or formal assessment of the grazing capacity of the Baviaanskloof was included in this study. Livestock is however a key farming activity deserving of mention in the context of the agricultural potential of the valley. The current livestock farming practices are much less dependent on the extensive grazing in the mountain areas, than in previous decades due to the a rate of stock losses due to predation by jackal, caracal and perhaps leopard, although the latter was not indicated as a major problem, by the farmers interviewed in this study. Animal husbandry practices has been adjusted to largely make use of planted pastures on the floodplain and only use the veld (mountain) grazing for cattle and mature animals of large breeds in the case of sheep.

The formal grazing capacity norms (Conservation of Agricultural Resources Act, Act 43 of 1983 - CARA) indicates a grazing capacity of 40 – 56 ha/LSU (large stock unit) for the mountain grazing and 24 ha/LSU for the valley floor. The area of the valley floor on the farming land is estimated at 5630 ha, implying a grazing capacity of only 235 LSU's. This figure does not take the grazing capacity of planted pastures into account, which could conservatively be 3 LSU's/ha on well maintained lucerne fields. When 50% of the ±740 ha of irrigated fields are planted to lucerne pastures, the combined grazing capacity would increase to ±1310 LSU's or, at a conversion rate of 6 small stock units (SSU) per LSU, 7860 SSU's. The estimated 35162 ha of mountain veld on the remaining farms have a combined grazing capacity of 730 LSU's.

12. Farming Sustainability

In summary, the summer climate is warm to hot with low humidity and rainfall. The winters are dry and cool to cold, with moderate frost and chill accumulation in the lower parts to severe frost and high chill accumulation in the higher western part. The groundwater supply appears to be abundant in most parts of the valley and the present use is found to be sustainable. The soils are generally deep, with good permability and water retention and without significant acidity or salinity problems. These conditions should provide a sound basis for a thriving agronomic industry, which is not the case. The three main constraints on the agricultural potential of the Baviaanskloof are:

- Restricted access to market
- Unviable size of most farm units
- Poor logistical support

12.1 Access to market

Profitability in agriculture is often closely linked to the characteristics of the market, in terms of size, timing, quality requirements and access. Markets normally compensates well in terms of price, in times of under supply. A small market and or wide production base often lead to over supply and deflated producer prices. In times of over supply, quality requirements are often used to restrict access to the market.

Simple logistical reasons can however also limit access to the market, as in the case of the Baviaanskloof. The road via the Wilderness Area (eastern access) cannot be used for the transport of produce out of the valley. From Studtis to Port Elizabeth, via Uniondale and the Langkloof (western access) is 360 km and to Cape Town via R62 is ±600 km. Transport cost and travel time is therefore a logistical challenge and has in the past, led to preference for high value, low volume (and weight) products such as vegetable seed. This should however not be seen as an absolute restriction. When the product and timing to the market is favourable, it may warrant the transport cost and infrastructure. The export of early table grapes from Ausenkehr (Namibia) to Europe via Cape Town can be used as an example.

12.2 Size of farm units

An assessment of the size of arable land (recently cultivated and current productive fields) on each farm and the number of sheep or cattle that it can accommodate when theoretically fully planted to irrigated lucerne, yielded the following results.

Table 12: Analysis of viability of farm unit size

Farm	Total Area (ha)	Arable[1] Area (ha)	Farms with arable land larger than:				Livestock on lucerne[2]	
			40 ha	60 ha	80 ha	100 ha	LSU	SSU
1	206	25.8	NO	NO	NO	NO	77	464
2	547	2.6	NO	NO	NO	NO	8	47
3	565	15.2	NO	NO	NO	NO	46	274

Farm	Total Area (ha)	Arable[1] Area (ha)	Farms with arable land larger than:					Livestock on lucerne[2]	
			40 ha	60 ha	80 ha	100 ha		LSU	SSU
4	1481	85.6	**YES**	**YES**	**YES**	NO		257	1541
5	326	0	NO	NO	NO	NO		0	0
6	347	2.0	NO	NO	NO	NO		6	36
7	689	1.7	NO	NO	NO	NO		5	31
8	6610	61.8	**YES**	**YES**	NO	NO		185	1112
9	1566	44.2	**YES**	NO	NO	NO		133	796
10	1963	35.4	NO	NO	NO	NO		106	637
11	2008	0	NO	NO	NO	NO		0	0
12	500	24.3	NO	NO	NO	NO		73	437
13	1416	86.8	**YES**	**YES**	**YES**	NO		260	1562
14	2167	25.7	NO	NO	NO	NO		77	463
15	613	0	NO	NO	NO	NO		0	0
16	179	0	NO	NO	NO	NO		0	0
17	1117	29.7	NO	NO	NO	NO		89	535
18	823	69.6	**YES**	**YES**	NO	NO		209	1253
19	7899	186.3	**YES**	**YES**	**YES**	**YES**		559	3353
20	1730	0	NO	NO	NO	NO		0	0
21	8040	44.7	**YES**	NO	NO	NO		134	805
TOTAL	**40 792**	**741.4**	**7**	**5**	**3**	**1**		**2224**	**13345**

1 Only areas recently cultivated or under active production, as determined from 2009 aerial photography.
2 Figures are for LSU's OR SSU's not both.

Although some high value crop types can be viable on small farms (e.g. strawberries), they normally require very good access to market and support infrastructure, due to cold chain requirements or short shelf live or other quality related factors. For most of the main stream crop types a minimum of 40 ha is often viewed as the smallest size to attain viability and optimise use of labour, implements and equipment. When farming with lower value crops, or under sub-optimum conditions – including being far from the market – the minimum required area rapidly increases. Fourteen of the 21 farms have access to less than 40 ha of suitable arable land, while only one farm has more than 100 ha of cultivated land.

When 800 small stock units are set as the minimum to achieve a viable farm size, there are again only seven viable farms, when all cultivated fields are planted to lucerne pastures and are fully irrigated. This practice will however result in an escalation of water required for irrigation as the water use of lucerne is high. A total of 741 ha @ 11851 m^3/a will require 8.8m m^3 per annum, which exceeds the 7.9 m m^3 estimated as the recharge potential of the Alluvial aquifer and can thus not be considered sustainable.

12.3 Logistic Support

Intensive farming requires an efficient and reliable supply of inputs like fertiliser, pesticides, herbicides, seed/plant material, fuel, repair and maintenance, technical advice, etc. These services and commodities are largely unavailable in the Baviaanskloof, whilst the nearest town (Willowmore) only services a largely Karoo-type farming community. The lack of logistical support is therefore regarded as a real limiting factor in the agricultural development and activities of the Baviaanskloof.

13. Possible alternatives

This study does not seek to prescribe farming activities to the farmers of the Baviaanskloof, nor can it investigate all alternative opportunities. It merely wishes to list a number of crops and or other ventures that are considered possible alternatives that may warrant further investigation into its viability.

The Baviaanskloof, being so geographically well defined, isolated and unique, certainly provides an excellent opportunity for any GI (geographical indication) product or range of products. It is already used to some extent by the conservation and tourism fraternity, but can definitely be extended to other products and even services. Being rather small in size, it is suggested that any future plan for the Baviaanskloof includes a clear strategy for the incorporation of this branding opportunity from farm products (e.g. vegetable seed, venison, olive oil, etc.) to eco and agri tourism services (e.g. guided overnight wilderness trails).

13.1 Private Nature Reserve

The formation of a private nature reserve that spans all (most) mountain land of the remaining farms and allows for game farming, tourism and/or hunting concessions and continuation of other farming activities on the flood plain, has been identified by the Baviaanskloof Hartland Initiative as a possible outcome.

Fencing off the extensive grazing mountain land and incorporating it into a formal private nature reserve will imply the withdrawal of livestock farming and thus a change in land use. This may necessitate an application for rezoning in terms of the Subdivision of Agricultural Land Act (SALA, Act 70 of 1970). Given the low grazing capacity of this 35 162 ha of land – 730 LSU's – the impact of such a rezoning is deemed to be low.

13.2 Game Breeding

Game breeding programmes of high value species – tuberculosis free buffalo, sable or others – on an intensive scale, perhaps combined with facilities like breeding or quarantine bomas on planted pastures on the flood plain, could be considered in conjunction with the private nature reserve. Apart from additional income streams it may also strengthen the tourism potential.

13.3 Alternative crops

Besides the normal viability and sustainability requirements, the following guidelines are offered as selection criteria for any alternative crop to be established in the Baviaanskloof:

- Is it very uniquely suited to the climate of the Baviaanskloof?
- Does it offer processing and/or value adding potential?
- Will it contribute to the agri/eco tourism potential of the valley?
- Can it capatalise on GI branding?
- Is it compatible with the conservation agenda?

The concept of produce processing, to a level where it can be GI branded, is considered the best way to increase farming profitability. For most crops, this should result in a smaller (or lighter) product that needs to be transported and it could support the tourism initiatives. Innovative thinking is required here to establish micro industries – capable of attracting grant funding for startup capital, create new job opportunities and offer empowerment potential – that captures the fascination of consumers and or tourists. The following are three examples:

- Wine cellar
- Cigar factory
- Essential oil extraction plant

13.3.1 Wine Cellar

The climate, soils and water provides an opportunity for premium wine grape production of selected varieties. Mean ripening temperatures are comparable with the Breede River Valley, while the rainfall in January, February and March are similar to Groot Constantia. Humidity is low, which should reduce the fungal disease pressure. It is however, the apparent absence of extreme heat wave (40°C +) events, that renders the area very suitable for wine grape production.

A wine cellar should be very compatible with tourism and could even result in a world class product. The production of wine grapes, to be sold into the open market is not considered a viable option.

13.3.2 Cigar Factory

Tobacco is a traditional crop of the Baviaanskloof. The processing of the tobacco into a high value, niche market product such as cigars, is perhaps a unique opportunity.

13.3.3 Essential Oils

The climate is suitable for the production of a selection of essential oil plants. Oil extraction can be done on a small scale and thus create a micro industry that can target niche markets worldwide.

13.3.4 Other Crops

Other popular "alternative crops" such as figs and pomegranates are not considered viable options for the Baviaanskloof. Figs for the fresh market are a very delicate product and require a cold chain from harvest to the market and most likely a daily transport to deliver ripe fruit. Pomegranate is less delicate and can be processed to pomegranate juice. Such a facility will require some joint venture or co-operative agreement, to extend the production area to 200 ha or more to attain economy of scale and viability.

Pecan nuts have been mentioned by some farmers as a possible alternative crop. The climate and soils are suitable, therefore growing and production is possible. It is however a crop that requires a very long term strategy, without any real processing opportunity. The input costs are relatively low and therefore some farmers may convert some fields to pecans. It is however not a crop that will intensify agricultural activity, upscale cash flow and create job opportunities over the next 5 to 10 years.

13.4 Carbon Trading

Given the existing initiatives around spekboom plantings for veld restoration and possible carbon trading, this opportunity should be developed further.

14. Literature

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APPENDIX:

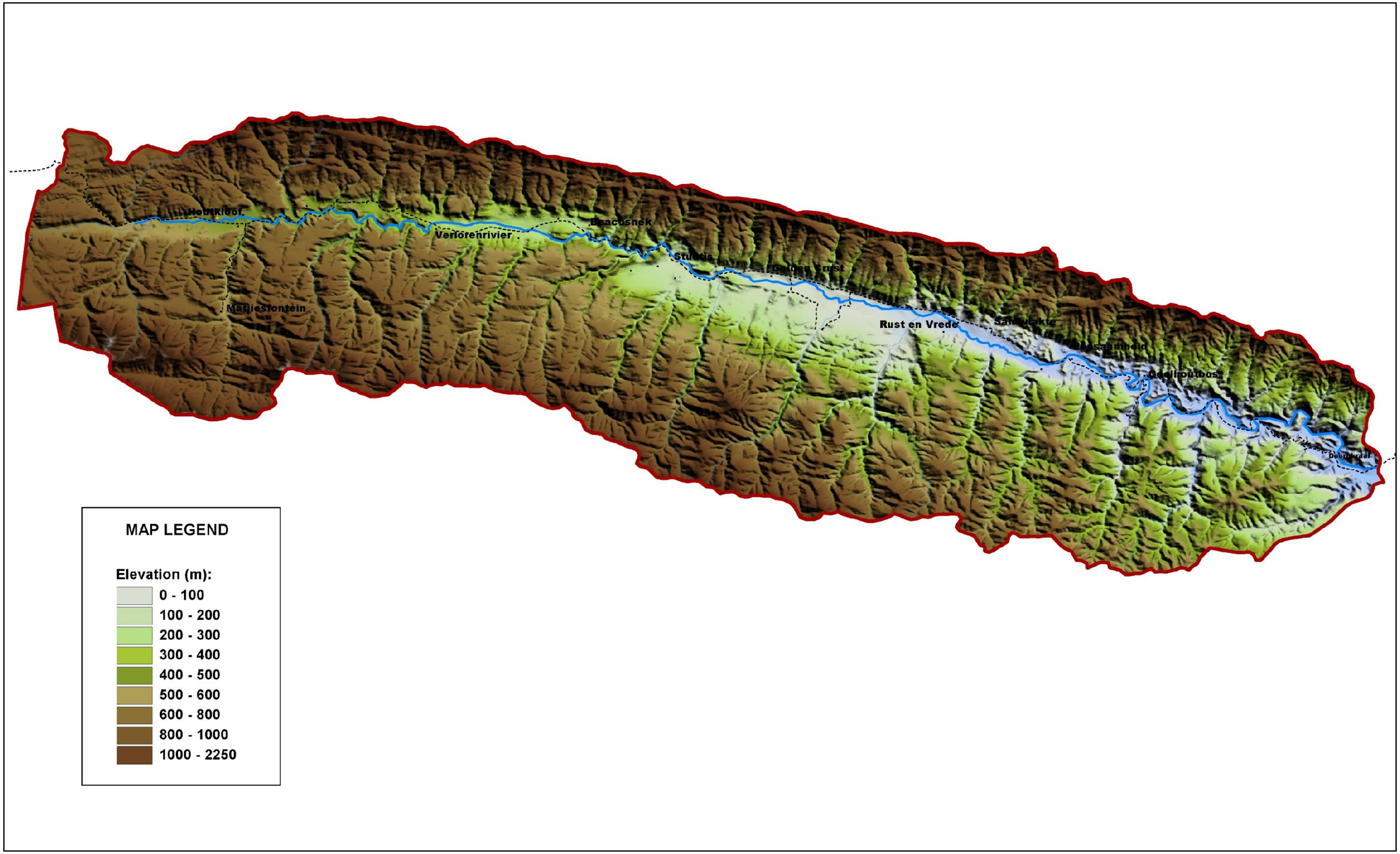
MAP: Digital Elevation Model

MAP: Cultivated Fields

MAP: Soil Survey Points

Climate summary

Soil Analysis Results



DATA SOURCES:
Elevation data derived from 20 m contours, provided by Chief Directorate: National Geospatial Infomation.

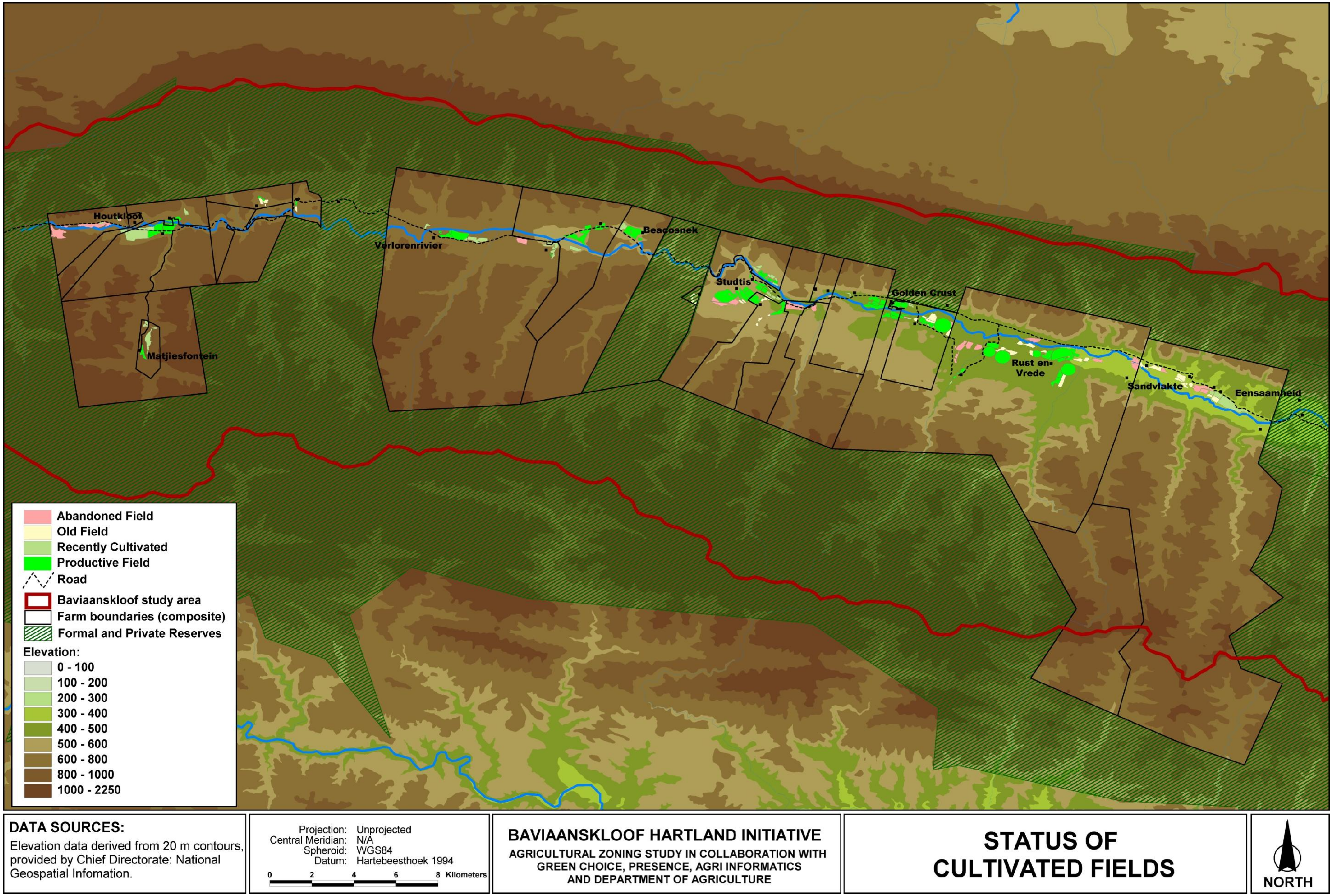
Projection: Unprojected
Central Meridian: N/A
Spheroid: WGS84
Datum: Hartebeesthoek 1994

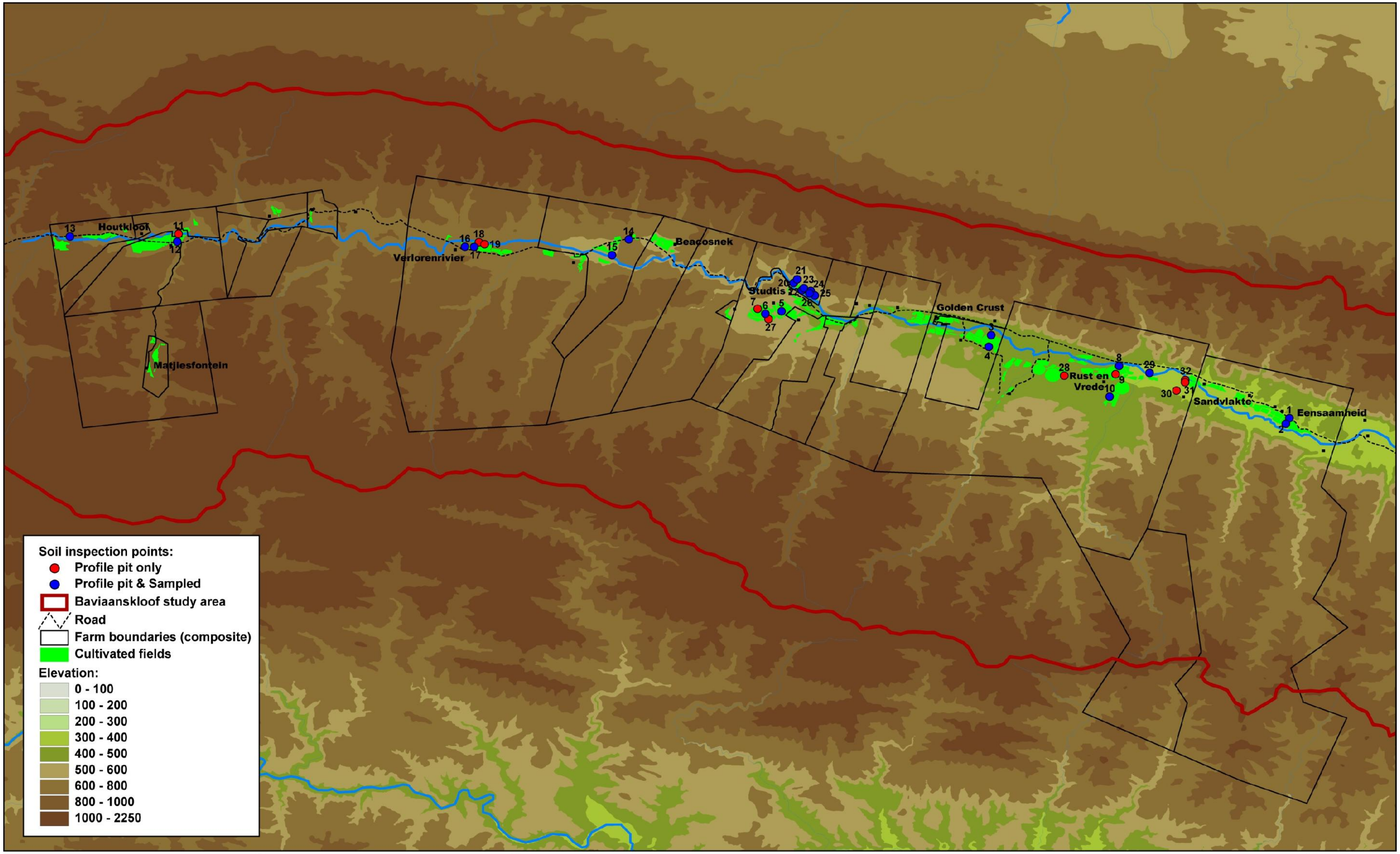
0 5 10 Kilometers

BAVIAANSKLOOF HARTLAND INITIATIVE
AGRICULTURAL ZONING STUDY IN COLLABORATION WITH GREEN CHOICE, PRESENCE, AGRI INFORMATICS AND DEPARTMENT OF AGRICULTURE.

DIGITAL ELEVATION MODEL

NORTH


Houtkloof
Verlorenrivier
Beacosnek
Matjiesfontein
Studtis
Golden Crust
Rust en Vrede
Sandvlakte
Eensaamheid
Abandoned Field
Old Field
Recently Cultivated
Productive Field
Road
Baviaanskloof study area
Farm boundaries (composite)
Formal and Private Reserves
Elevation:
0 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 800
800 - 1000
1000 - 2250
DATA SOURCES:
Elevation data derived from 20 m contours, provided by Chief Directorate: National Geospatial Infomation.
Projection: Unprojected
Central Meridian: N/A
Spheroid: WGS84
Datum: Hartebeesthoek 1994
0 2 4 6 8 Kilometers
BAVIAANSKLOOF HARTLAND INITIATIVE
AGRICULTURAL ZONING STUDY IN COLLABORATION WITH GREEN CHOICE, PRESENCE, AGRI INFORMATICS AND DEPARTMENT OF AGRICULTURE
STATUS OF CULTIVATED FIELDS
NORTH



DATA SOURCES:

Elevation data derived from 20 m contours, provided by Chief Directorate: National Geospatial Infomation.

Projection: Unprojected
Central Meridian: N/A
Spheroid: WGS84
Datum: Hartebeesthoek 1994

0 2 4 6 8 Kilometers

BAVIAANSKLOOF HARTLAND INITIATIVE

AGRICULTURAL ZONING STUDY IN COLLABORATION WITH GREEN CHOICE, PRESENCE, AGRI INFORMATICS AND DEPARTMENT OF AGRICULTURE

SOIL SURVEY POINTS

NORTH

Climate data summary

BAVIAANSKLOOF 1 33°33'S 24°4'E Altitude (approx) 450 m Record length 27 Yrs

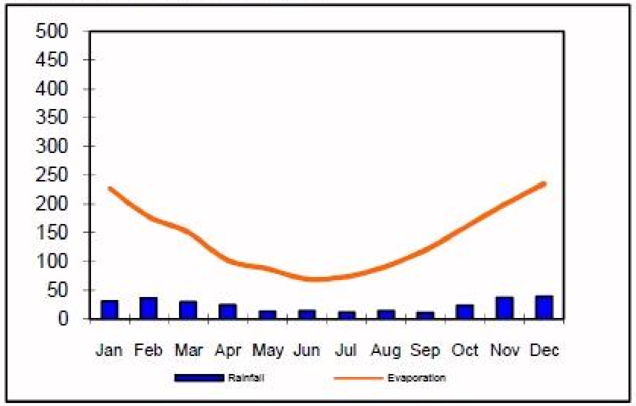
	Temperature °C										Degree Days above 10°C									
	Av. Mthly Days T < 0 °C	Av. Mthly Lowest Min.	Av. Mthly Min.	Av. Min. minus Lowest Min.	Daily Mean	Daily Range	Av. Mthly Max.	Av. Mthly Highest Max.	Highest Max. minus Av. Max.	Temp. Variability Index	Unadj. without Cutt-off	Unadj. with 19° Cutt-off	Adj. for Lat. & Day Length	Av. Sunshine Hours	Av. Number Rain Days	Av. Rainfall mm	Av. A-pan Evap. mm	Av. Windrun km	Av. Daily Min. % R.H.	Av. Daily Max. % R.H.
January	0.0	15.1	16.3	1.3	23.4	14.2	30.5	32.5	2.0	31.6	416	279	274	278	0.0	32	228	5943	24	81
February	0.0	14.9	16.8	1.9	23.7	13.9	30.6	32.4	1.8	31.4	384	252	248	230	0.0	37	178	4883	24	82
March	0.0	12.5	15.1	2.6	22.0	13.7	28.8	31.6	2.8	32.8	371	279	274	232	0.0	30	151	4546	25	83
April	0.0	9.7	11.8	2.1	18.8	13.9	25.7	29.0	3.3	33.2	263	272	267	205	0.0	25	102	3444	24	83
May	0.0	6.8	8.8	2.0	15.9	14.3	23.1	26.0	3.0	33.6	183	183	180	199	0.0	13	87	3108	22	80
June	0.0	3.6	5.9	2.3	13.0	14.2	20.1	22.9	2.7	33.5	91	91	89	186	0.0	15	69	3042	21	76
July	0.0	3.4	5.3	2.0	12.7	14.7	20.1	22.6	2.5	33.9	84	84	82	206	0.0	12	74	3242	21	75
August	0.0	3.8	6.5	2.7	13.9	14.9	21.4	24.6	3.2	35.7	122	122	120	224	0.0	14	92	3829	23	76
September	0.0	4.8	8.4	3.6	16.1	15.4	23.8	26.2	2.4	36.8	184	184	181	232	0.0	12	120	4571	21	80
October	0.0	8.4	11.1	2.8	18.2	14.2	25.3	28.0	2.8	33.9	254	254	250	238	0.0	24	159	5321	23	80
November	0.0	10.3	13.1	2.8	20.2	14.3	27.4	31.0	3.6	35.1	307	270	265	258	0.0	38	200	5548	23	79
December	0.0	10.1	14.7	4.7	21.9	14.4	29.1	32.0	2.9	36.3	370	279	274	284	0.0	40	235	6020	23	79
Annual					18.3	14.3			2.7	34.0	2285	1797	1766	2772	0	292	1694	53496	23	80

* (adapted from Gladstones, 1993)

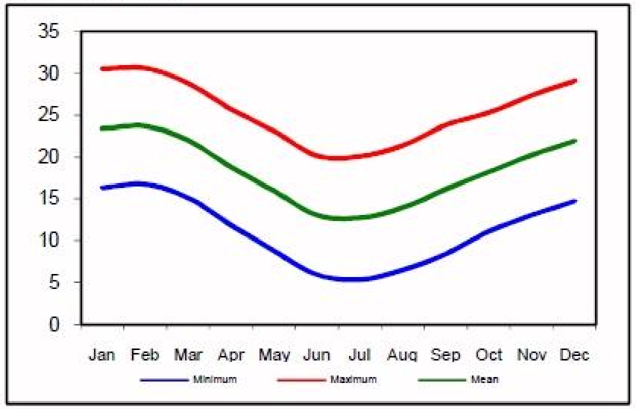
NOTE: 1. Degree days calculated for Sep to Mar (S Hemisphere) & Apr to Sep (N Hemisphere)

2. A column of zero values is an indicaton of an element not recorded at this weather station

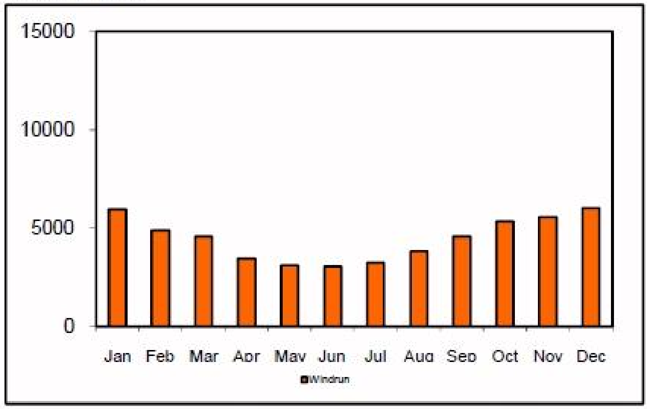
Rainfall and Evaporation (mm):



Temperature (°C):



Windrun (km):



Tonietto & Carbonneau's multicriteria climatic index:

Heliothermal Index	Cold Night Index	Dryness Index
Hot	Warm nights	Very dry
HI+2	CI-1	DI+2

Data sheet compiled by ***Agri Informatics***

All data are provided free of charge. Fees apply to data processing and extraction only.

Data sources: Agromet, division of ARC
FAO: Environment and Natural Resources Services
Müller & Hennings
WDC for Meteorology
WorldClimate.com

Soil analysis results for composite samples from profiles as indicated (Analysis by Elsenburg):

Sample	Profiles	Lab. No.	Diepte	Grond	pH	Weerst.	H^+	P Bray II	K	Uitruilbare katione (cmol(+)/kg)					Cu	Zn	Mn	C	Sand	Silt	Clay
			cm		KCl	Ohm	cmol/kg	mg/kg		Na	K	Ca	Mg	T-Value	mg/kg			%	%		
BAV1A	1	PS/12/02644	30	SaLM	5.7	1250	-	18	175	0.31	0.45	4.35	1.82	6.94	0.76	2.02	131.90	0.81	77	10	13
BAV1B	1	PS/12/02645	60	LmSa	6.0	2320	-	7	41	0.09	0.10	2.23	1.05	3.48	0.43	0.61	40.21	0.29	85	4	11
BAV2A	2	PS/12/02646	30	LmSa	6.0	2050	-	52	206	0.10	0.53	2.99	1.06	4.69	0.58	2.53	33.48	0.51	84	7	9
BAV2B	2	PS/12/02647	60	SaLM	5.8	2630	-	29	41	0.06	0.10	2.24	0.85	3.26	0.46	1.71	20.39	0.34	88	5	7
BAV3A	3	PS/12/02648	30	LmSa	7.9	880	-	47	206	0.30	0.53	9.70	2.44	12.97	1.06	2.54	80.58	1.17	84	7	9
BAV3B	3	PS/12/02649	60	SaLM	8.1	150	-	67	103	2.05	0.26	11.75	4.72	18.8	1.09	1.80	46.19	1.38	76	11	13
BAV4A	4	PS/12/02650	30	SaLM	7.9	380	-	97	240	0.60	0.61	24.60	4.80	30.62	1.59	3.25	313.70	0.98	68	15	17
BAV4B	4	PS/12/02651	60	SaLM	8.0	340	-	52	168	0.75	0.43	22.40	5.12	28.71	1.29	2.71	276.00	0.77	68	15	17
BAV5A	5	PS/12/02652	30	SaClLm	6.8	790	-	141	273	0.10	0.70	7.05	2.24	10.1	2.54	4.22	550.20	0.79	66	13	21
BAV5B	5	PS/12/02653	60	SaLM	7.1	910	-	237	116	0.31	0.30	9.30	2.96	12.88	2.15	1.19	438.70	0.14	78	9	13
BAV6A	6	PS/12/02654	30	SaLM	7.9	420	-	191	448	0.57	1.15	13.79	3.10	18.62	2.33	2.92	557.20	0.63	76	9	15
BAV6B	6	PS/12/02655	60	SaLM	7.7	590	-	78	120	0.80	0.31	13.89	3.31	18.32	2.02	0.84	429.00	0.22	76	11	13
BAV8A	8	PS/12/02656	30	LmSa	5.1	300	1	46	129	0.94	0.33	3.25	1.83	7.35	0.66	3.30	7.80	1.31	82	7	11
BAV8B	8	PS/12/02657	60	LmSa	3.7	570	1.93	20	41	0.63	0.10	0.85	0.68	4.2	0.63	0.85	0.44	0.74	82	7	11
BAV10A	10	PS/12/02658	30	SaClLm	7.8	330	-	183	379	0.83	0.97	17.89	6.03	25.73	2.71	3.43	160.40	0.85	56	17	27
BAV10B	10	PS/12/02659	60	Cl	7.4	160	-	52	133	2.06	0.34	8.64	4.47	15.52	2.69	1.22	291.70	0.65	26	29	45
BAV12A	12	PS/12/02660	30	SaLM	5.2	1020	0.54	20	55	0.15	0.14	3.10	1.30	5.23	1.16	2.26	136.90	0.66	74	11	15
BAV12B	12	PS/12/02661	60	SaLM	5.5	1610	-	30	38	0.34	0.10	4.65	2.13	7.23	1.41	1.59	94.26	0.91	66	17	17
BAV13A	13	PS/12/02662	30	SaLM	5.1	4220	0.62	23	58	0.05	0.15	2.85	0.74	4.41	0.45	1.06	35.39	0.7	78	11	11
BAV13B	13	PS/12/02663	60	SaLM	5.0	2190	0.9	42	42	0.18	0.11	3.99	1.40	6.58	1.01	1.29	57.42	1.03	70	13	17
BAV14A	14	PS/12/02664	30	LmSa	8.0	900	-	178	398	0.16	1.02	29.60	8.19	38.97	2.22	1.85	302.10	0.37	82	7	11
BAV14B	14	PS/12/02665	60	SaLM	8.3	150	-	101	598	3.53	1.53	58.60	13.44	77.11	1.74	1.00	18.70	0.23	78	11	11
BAV15A	15	PS/12/02666	30	SaLM	5.9	970	-	71	210	0.15	0.54	5.08	1.79	7.57	1.13	2.90	214.40	1.24	68	15	17
BAV15B	15	PS/12/02667	60	SaLM	6.1	1230	-	21	45	0.10	0.12	2.02	0.77	3.02	0.46	0.66	48.87	0.29	90	3	7
BAV16A	16	PS/12/02668	30	SaLM	7.9	880	-	158	187	0.36	0.48	61.90	9.15	71.9	0.82	1.35	14.55	0.68	78	11	11
BAV16B	16	PS/12/02669	60	LmSa	7.8	830	-	144	66	0.69	0.17	54.85	7.85	63.57	0.64	0.45	7.76	0.28	82	9	9
BAV17A	17	PS/12/02670	30	SaLM	6.3	2530	-	30	47	0.05	0.12	1.88	0.62	2.68	0.26	1.27	29.32	0.4	94	1	5
BAV17B	17	PS/12/02671	60	LmSa	6.2	2760	-	69	133	0.10	0.34	3.01	1.14	4.6	0.93	2.49	160.40	0.36	86	5	9
BAV20A	20	PS/12/02672	30	LmSa	6.2	1020	-	56	205	0.21	0.52	2.56	0.92	4.22	0.85	3.04	92.87	0.44	86	5	9
BAV20B	20	PS/12/02673	60	LmSa	6.2	1830	-	28	86	0.10	0.22	2.74	1.13	4.2	0.74	0.61	63.30	0.27	86	3	11
BAV21A	21	PS/12/02674	30	LmSa	8.0	1580	-	70	293	0.07	0.75	9.38	2.36	12.57	1.69	3.48	435.70	0.43	82	7	11
BAV21B	21	PS/12/02675	60	SaLM	8.1	1470	-	20	115	0.39	0.29	26.57	3.30	30.57	0.67	0.67	177.10	0.16	90	3	7
BAV22A	22	PS/12/02676	30	LmSa	6.0	2010	-	113	107	0.13	0.27	4.20	1.32	5.93	1.47	7.53	203.10	0.61	86	3	11
BAV22B	22	PS/12/02677	60	SaLM	6.6	2370	-	55	107	0.14	0.27	6.36	2.01	8.79	1.27	1.22	183.20	0.7	72	13	15
BAV23A	23	PS/12/02678	30	SaLM	6.4	1580	-	67	168	0.51	0.43	3.48	1.49	5.92	1.42	2.85	246.20	0.47	76	7	17
BAV23B	23	PS/12/02679	30	SaLM	6.3	1440	-	25	74	0.53	0.19	3.36	1.72	5.81	1.03	1.28	167.20	0.29	78	5	17

Sample	Profiles	Lab. No.	Diepte	Grond	pH	Weerst.	H^+	P Bray II	K	Uitruilbare katione (cmol(+)/kg)					Cu	Zn	Mn	C	Sand	Silt	Clay
			cm		KCl	Ohm	cmol/kg	mg/kg		Na	K	Ca	Mg	T-Value	mg/kg			%	%		
BAV24A	24	PS/12/02680	60	SaLM	6.1	3150	-	41	122	0.07	0.31	1.41	0.60	2.4	0.47	2.06	100.40	0.23	88	3	9
BAV24B	24	PS/12/02681	30	SaLM	5.6	2260	-	22	51	0.08	0.13	1.16	0.51	1.89	0.36	1.14	72.46	0.12	88	3	9
BAV25A	25	PS/12/02682	60	LmSa	6.4	2220	-	62	184	0.07	0.47	3.28	0.93	4.76	1.07	3.16	103.30	0.78	84	5	11
BAV25B	25	PS/12/02683	30	SaLM	5.9	7080	-	13	24	0.03	0.06	0.80	0.20	1.1	0.13	0.19	3.96	0.09	94	1	5
BAV26A	26	PS/12/02684	30	LmSa	6.2	5160	-	27	87	0.08	0.22	1.83	0.73	2.88	1.02	4.99	63.42	0.26	86	5	9
BAV26B	26	PS/12/02685	60	LmSa	6.0	3260	-	15	64	0.11	0.16	2.06	1.08	3.42	0.72	0.56	60.76	0.2	84	3	13
BAV29	29	PS/12/02686	60		3.4		13.02	134	121	1.35	0.31	2.20	1.25	18.13	1.78	3.13	7.30	12.25			