SAB The South African Breweries

WWF

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of Federal Republic of Germany The Federal Government

SOUTH AFRICAN BREWERIES: WATER STEWARDSHIP IN THE HOPS INDUSTRY

A Shared Water Risk Assessment by the Water Futures Partnership


WATER
GIVES US BALANCE
What would Castle Lager be without the finest quality filtered water? It wouldn't be the same refreshing and great tasting beer. Charles Glass knew if you want to brew an iconic beer for South Africans, you must only use the finest water, barley, hops and maize product. After all, it all comes together with a Castle, since 1895.
It all comes together with a Castle.
Homegrown
HOPS
MAKES ALL THE DIFFERENCE
Castle Lager celebrates the unique contribution of Africa's only commercial hop growing area on the foothills of the Outeniqua Mountains in George. These hops from George capture that amazing somewhat dry, somewhat bitter taste that differentiates our brew. So celebrate with your mates the coming together of hops, barley, maize product and water in South Africa's iconic beer, Castle Lager, since 1895.
all comes together with a Castle

The Water Futures Partnership

Water is an essential resource jointly used by communities, agriculture, business and government. Damage to ecosystems through the depletion and pollution of water resources has far reaching and potentially irreversible consequences. Measures taken by individual businesses to improve water usage have limited impact, especially if other stakeholders continue unsustainable practices and regulatory systems remain weak. Yet, there is increasing awareness that poorly managed water resources pose risks to water users, including reputational risks to businesses.

The strategic alliance between Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, SABMiller, the world's second largest beer producer, and WWF, a world leading conservation organisation, aims to assess and reduce shared water risks to strengthen water stewardship and governance in specific watersheds in four focus countries: South Africa, Tanzania, Ukraine and Peru.

The South African Water Futures Partnership is based on this foundation and consists of The South African Breweries Limited (SAB), GIZ in South Africa and WWF-SA.

About WWF

WWF is one of the world's largest and most respected independent conservation organisations, with almost 5 million supporters and a global network active in over 100 countries.

WWF South Africa

WWF South Africa is a national office that is part of the WWF network. We are a local NGO that for more than 40 years has worked towards the aim of inspiring all South African to live in harmony with nature, for the benefit of our country and the well-being of all our people.

At WWF-SA, we work to inspire and empower all South Africans, from school children and local community leaders to consumers and CEO's, to value, respect and defend the integrity of the natural ecosystems that underpin the sustainable development in our country.

About GIZ Working efficiently, effectively and in a spirit of partnership, we support people and societies worldwide in creating sustainable living conditions and building better futures. The services delivered by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH draw on regional and technical competence and tried and tested management expertise. Since 1 January 2011, GIZ has brought together under one roof the capacities and long-standing experience of three organisations: the Deutscher Entwicklungsdienst (DED) gGmbH (German Development Service), the Deutsche Gesellschaft für Technische Zusammenarbeit (GIZ) GmbH (German technical cooperation) and Inwent – Capacity Building International, Germany. As a federal enterprise, we support the German Government in achieving its objectives in the field of international cooperation for sustainable development. We are also engaged in international education work around the globe. GIZ is active in the region of the Southern African Development Community (SADC), and is involved in trans-boundary water management. As part of this involvement, we support work aimed at increasing the long term sustainability of the strategic water resources, both in terms of quantity and quality of available water. We recognise the importance of both the commercial and the community needs for access to secure supplies of water and seek ways in which we can facilitate partnerships that result in common benefit in this regard.

Foreword

Water is a sustainable development priority for The South African Breweries Limited (SAB). Water risk is particularly important to company's operations in some parts of South Africa which is a semi-arid and water scarce country. Brewing beer is a water-intensive process and ensuring ongoing water supplies is critical to the survival of SAB as a business, as well as to the communities in which the company operates. The way in which this scarce resource is managed is therefore very important.

SAB's Water strategy is driven by the company's Sustainable Development Priority to "make more beer, using less water". The strategy has a comprehensive risk-based approach in managing water within the business and value chain. SAB was one of the first companies to undertake a detailed water foot printing study, which revealed that more than 85% of water used across the value chain of a beer rests in the agricultural supply chain. For SAB this relates primarily to the barley and hops we use to brew the good quality beers the company has become famous for.

The first step was to identify the possible risks facing SAB in the hops industry, which is concentrated in the South-Western Cape area of George. This was an ideal first project for the Water Futures Partnership of SAB with WWF and GIZ – which brought together key stakeholders in the water-risk landscape within which the SAB hops farms operate. Hops is a critical ingredient in a beer, but makes up a very small component of the final product. SAB decided to kick off the water risk process in this industry as it is a relatively small part of the value chain and ideal to test our approach and assumptions about water management. Working closely with WWF, CSIR and local stakeholders, a water-risk assessment was undertaken, and the consequences from likely future scenarios developed. Careful attention is taken to understand the implications of the local hydrology, climate change patterns, socio-economic development and agronomic realities.

It is clear that corporations engaging in strategic water stewardship are more likely to succeed if they walk this journey with experienced partners. SAB would like to thank and acknowledge the important roles and contributions of GIZ and WWF in guiding and supporting us as we explore the optimal role for a brewing company in water stewardship.

The local Water Futures Partnership would also like to acknowledge the contributions of the global partners (SABMiller, WWF and GIZ), the local stakeholders who participated in consultation process and the various contributors to research and analysis. The professional contribution from the CSIR team is greatly appreciated. The next step is to map out appropriate response strategies based on the insight gained during this exciting project.

We have decided to publish the findings of the shared water risk analysis in the hops producing area as a contribution to the broader debate about the role of corporations in securing sustainable water provision into the future. Ensuring adequate supply of the quality and quantity of water required is essential for human development, economic growth and environment integrity.

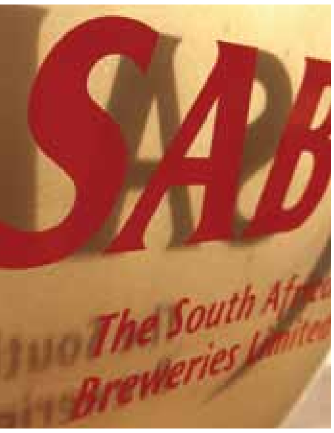
Reading this publication it is possible to focus on the detailed analysis of the specific findings of the water risks facing SAB and other stakeholders in the hops producing George water landscape. At the same time, the reader is able to reflect on the complexity of water risk from a corporate perspective, particularly as it relates to a company's supply chain. Finally, this document outlines the potential for corporations to demonstrate water stewardship by working with others to identify and quantify shared water risks and then to map out carefully considered response strategies based on environmental integrity, economic logic and local social realities. This approach can be an important contribution to a sustainable future.

SAB and our partners, GIZ and WWF, look forward to walking the journey towards water stewardship with our stakeholders and friends in securing a more prosperous and sustainable world while building a more resilient company that will be a model 21st century competitor.

Vincent Maphai
Executive Director of Corporate Affairs and Transformation

Water is a sustainable development priority for The South African Breweries Limited (SAB).

SAB Corporate Profile



The South African Breweries Limited (SAB) was established in 1895 and is the South African subsidiary and historical birthplace of SABMiller plc, the world's second largest brewer by volume.

SAB is the second largest listed company on the JSE Securities Exchange, South Africa's leading producer and distributor of alcoholic and non-alcoholic beverages and one of the nation's largest manufacturing firms.

The company operates seven breweries and 42 depots in South Africa with an annual brewing capacity of 3.1 billion litres, selling an average of more than 2.5 billion litres per year.

The company's portfolio includes brands rich in local and international heritage such as Castle Lager, Hansa Pilsener, Carling Black Label and the iconic Dutch beer brand Grolsch.

SAB's soft drinks division is Amalgamated Beverage Industries (ABI), the largest producer and distributer of Coca-Cola brands in Southern Africa. With five state-of-the-art manufacturing plants in South Africa, ABI accounts for approximately 60% of Coca-Cola's sales in South Africa.

As well as its beer and soft drink division, SAB also owns a hop production company, The South African Breweries Hop Farms (Pty) Ltd; a barley farming company, The South African Breweries Barley Farms (Pty) Ltd; a barley malting company, The South African Breweries Maltings (Pty) Ltd; and a 60% share of the metal crown manufacturer, Coleus Packaging (Pty) Ltd.

Hops, along with water, maize and barley, are essential ingredients in the beer making process. The industry was established in the late 1930's and is internationally recognised as a world-class hops supplier. It is the only hops industry to be successful at low latitudes. Hops production is derived from about a dozen commercial hop farms; of which three belong to SAB. SAB's hop farms are located in the foothills of Outeniqua, in Blanco, just outside George. As a raw material, hops contain alpha and beta acids as well as essential oils, and it is the alpha ingredient in the hop plant that provides beer with a bitter taste. The present value of the industry is about R55m and creating job opportunities for about 1500 people. This small industry has succeeded against significant odds and it has saved SAB and the country hundreds of millions of rands in foreign exchange earnings.

1. Introduction: a sustainable development approach

SAB's approach to sustainable development

The South African Breweries Limited (SAB) has long played a role as one of South Africa's most socially progressive and innovative enterprises. The company understands that its business is not separate from society - it is an employer, a customer, a supplier and a taxpayer. The long-term interests of SAB and the wider community are therefore intertwined. Protecting our natural environment is part of our journey towards a more sustainable and prosperous future.

SAB has a clear approach to sustainable development, developed after consultation with internal and external stakeholders. The company brought all aspects of its sustainable development projects and priorities together under the banner 'Ten Priorities, One Future'.

The Ten SAB Sustainable Development Priorities are:

- Making more beer using less water
- Discouraging irresponsible drinking
- Reducing energy and carbon footprints
- Reducing the weight of packaging, reusing bottles and encouraging recycling
- Working towards zero waste operations
- Building supply chains that reflect the company's values and commitment
- Benefiting communities
- Contributing to the reduction of HIV/Aids
- Respecting human rights
- Transparency in reporting the company's progress

Using less energy and less water, and engaging meaningfully with employees, customers, suppliers and communities, makes good business sense. There is also a strong business case for developing a constructive dialogue with government and helping disadvantaged South Africans to reach their economic aspirations.

The journey towards water stewardship

SAB is increasingly engaged with water as both a natural resource and as a potential business risk. For us there is a clear business case to strive for water stewardship based on securing an adequate supply of good quality water and the fact that stakeholders such as consumers, regulators and investors are interested in understanding water risks and quality issues. In anticipation of these developments, SAB has developed a clear Game Plan for water stewardship.

- In the brewery: use less water to make more beer and manage effluent standards
- In the supply chain: work with suppliers and farmers to identify water risks and options to reduce water use across the value chain
- Water in communities: identify CSI projects that will provide safe drinking water to communities
- Water governance: keep water on SAB strategic and risk agenda, mobilise staff to save water, engage government on policy issues and deliver on the Water Futures Partnership

The Water Futures Partnership uses the term water stewardship to refer to water users taking the responsibility to promote the more sustainable use and management of water. They can only meaningfully do this by working to lessen their own usage of water in operations, along the value chains and through investments made. Water stewardship must also be based on an understanding of the shared water risks they face on a location specific basis and on engaging as one body to address these risks. One example of SAB water stewardship in the supply chain is where the company is working closely with small-scale farmers in Taung, using soil moisture measurement to inform irrigation. Research is being undertaken with the University of the Free State to determine a crop factor for barley and develop a computerised irrigation strategy. Improved irrigation timing for barley will improve producer's sustainability by cutting costs of unnecessary irrigation water and electricity. This project is part of our commitment to understand and reduce the water risks facing SAB, our farmers and other stakeholders.

Background to the project

By its very nature, brewing is a water-intensive process. The security of water into the future is critical to the survival of SAB as a business, as well as to the communities in which the company operates. The way in which the scarce resource is managed is therefore of vital importance.

SAB is deeply aware that the beers we brew are fundamentally dependent on the availability of good quality water and has entered into the Water Futures Partnership with the WWF and the GIZ with a view to taking a leadership position in corporate stewardship of water resources.

As part of this journey, SAB was one of the first companies to undertake a comprehensive study into its water footprint, which found that almost 85% of SAB's water footprint lies in the local production of crops such as barley, maize and hops.

Based on this understanding, the next phase of the partnership seeks to understand the specific water risks that may be faced by critical components of the value chain. Within South Africa it was decided to focus on hops production in the Southern Cape due to the precarious nature of water availability in this area and the recent droughts.

Overview of this publication

This document outlines the situational assessment of shared water risk in the South African hops industry. This is based on an in-depth analysis of the agronomic system, the social-economic realities on the ground and the likely impact of climate change on rainfall and seasonal temperatures. Due consideration is also given to the ecological system and the hydrology of the George region. An integrated systems view takes a first step in identifying the inter-related nature of the various water risk drivers. Future outlooks of change for the major risk drivers paint the likely futures SAB and the hops industry have to plan for. Finally, the various response strategies for consideration by SAB and hops farmers are outlined as a basis for future action.

We believe this is probably the most comprehensive shared water risk analysis in the hops industry ever undertaken anywhere in the world. As such we will use this path-breaking study to ensure water stewardship for this vital crop. We also hope it will inspire and inform other corporations to take a water stewardship approach. Ultimately, this is a journey of shared learning.

2. Situational Assessment

Analysis of the risks facing the stakeholders in the South African hops industry starts with a situated assessment. Getting to grips with the agronomic system is important to frame the study. A key socio-economic reality is high levels of poverty and unemployment in the areas. Looking forward, it is essential to anticipate the impact of climate change, especially on local temperature and rainfall patterns. A common response to these pressures is to tap into groundwater sources. SAB needs to anticipate potential competition for water resources and thus need to explore the hydrological features of the area.

The Agronomic System

The hop producing farms that supply SAB are primarily located in two catchments on the interior of the Outeniqua Mountains, just inland of the town of George (Figure 1). For purposes of this study we have divide these areas into two nested catchments which form hydrological and ecologically clear systems. We refer to these two nested catchments as the 'Waboomskraal' and 'Herold' catchments as indicated on the map.

It is important to understand the geographical and agricultural context of the hops industry in order to determine the water risks facing the company and other stakeholders. Other key factors are the hydrological and climate systems as well as the local ecology and the socio-economic realities.

Thirteen commercial hop growers cultivate some 483 ha of hops in this area, all delivering their hops to the drying facility at SAB Hop Farms Pty Ltd in George. There is a high level of asset fixity associated with these hop growing operations because of the significant capital outlays required for this type of farming. This limits the flexibility and resilience of farmers to absorb water risks that they may face.

Hop growing is a water intensive process, with plants requiring on average about 10,000m^3 of water per hectare per growing season (September to March; Figure 2). This means an annual requirement of about 5 million m^3 of which about 2.2 million m^3 will need to be irrigated. Irrigation water is applied using overhead sprinklers and

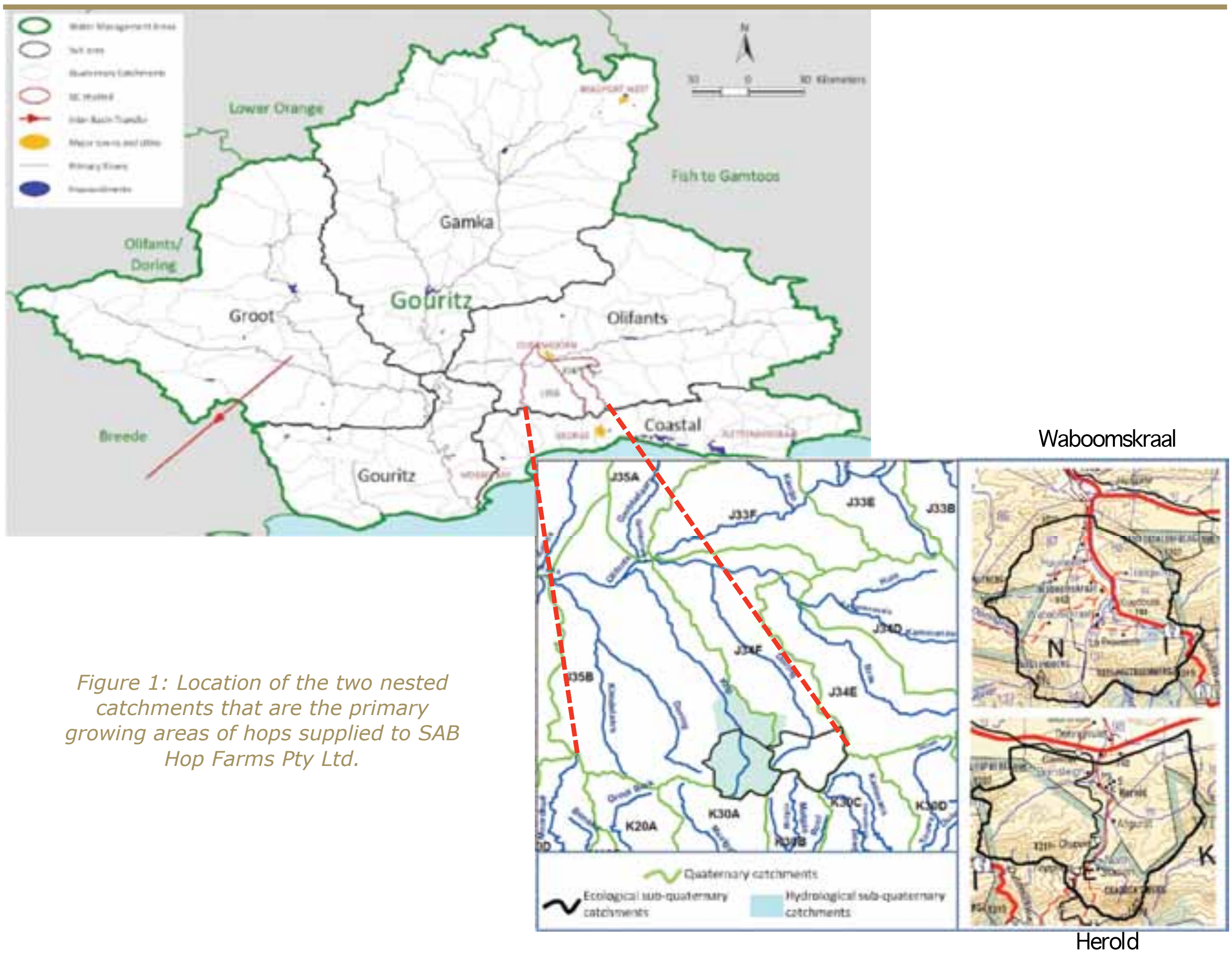
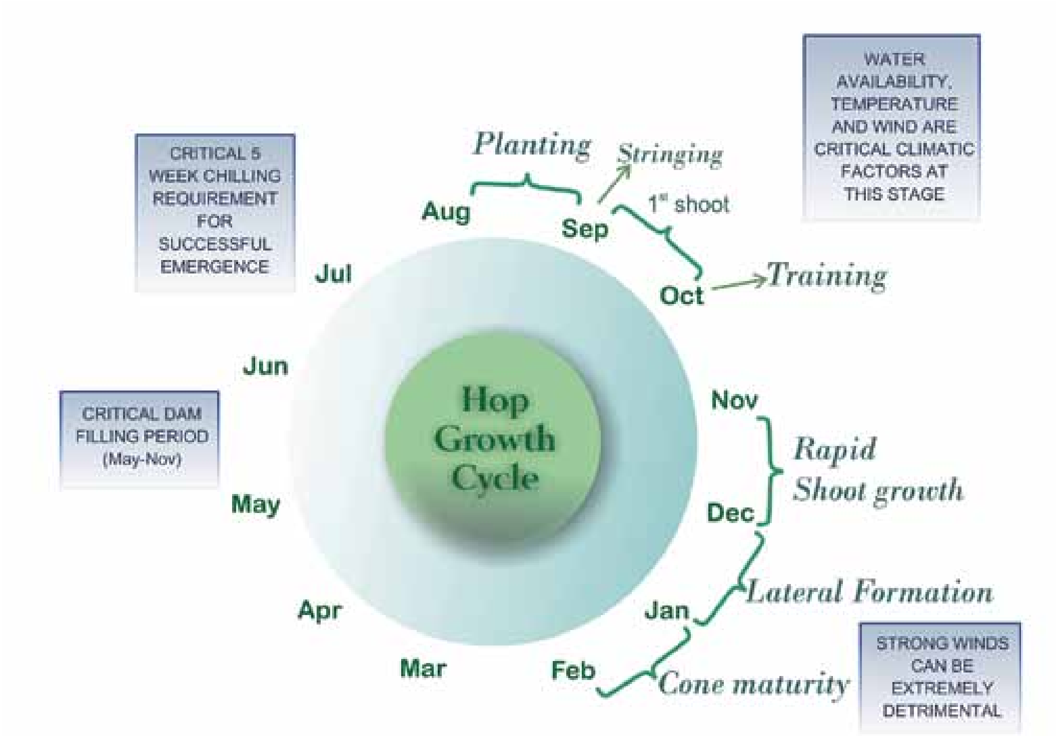


Figure 1: Location of the two nested catchments that are the primary growing areas of hops supplied to SAB Hop Farms Pty Ltd.



drip irrigation, although drip and micro-jets are slowly being phased out because of their high maintenance cost and their inferior ability to cool the plants during warm summers (despite their higher water efficiency).

Surface water storage capacity is around 1 million m^3 (i.e. less than half the irrigation requirement), with few options for further storage, and registered groundwater usage is around 200,000m^3. This makes it imperative that dams are filled during the dormant season (May to August) to provide enough water to stimulate the initial growth. In addition, dams need to be refilled at least once during the growing season to be able complete the growing cycle. Although no total crop failure has been recorded yet, this balance has been very precarious in a number of recent years during the drought. The hop growing cycle and water requirements are shown in Figure 2.

Hop farming is also reliant on a large number (ca. 1,000) of semi-skilled seasonal farm workers for training hop vines onto the strings (October) and harvesting (March). Labour comes mainly from the small rural town of Dysselsdorp.

The Climatic System

The Southern Cape is characterised by all-year rainfall with peaks in spring and autumn and the driest months in winter (Figure 3). Winter rainfall is associated with frontal bands, while summer rain is associated with tropical temperate rainfall bands.

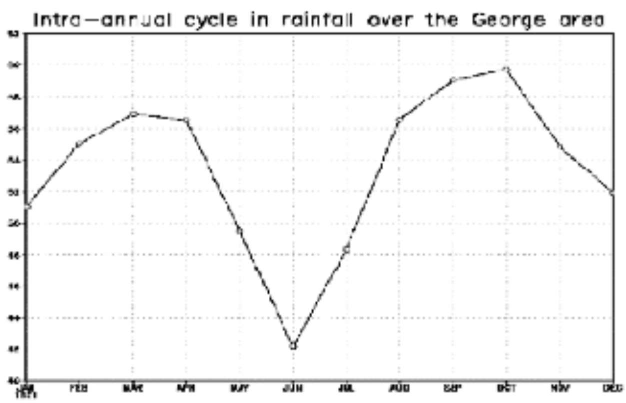


Figure 3: Average monthly rainfall in the Southern Cape Region.

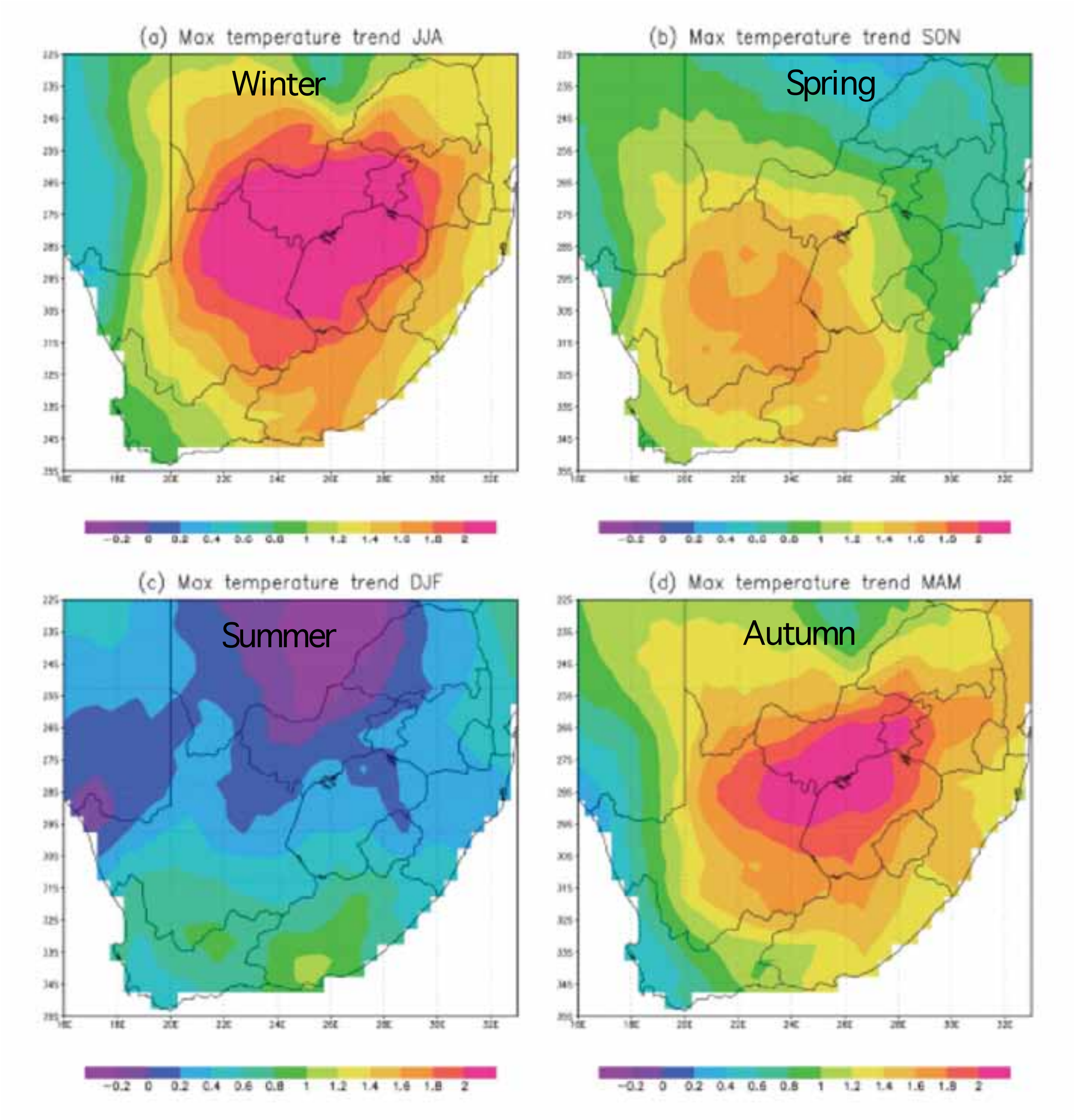


Figure 4: Observed trends in temperature over South Africa as recorded over the period 1901-2002. The seasonal months of winter (June, July, August), spring (September, October, November), summer (December, January, February) and autumn (March, April, May) are shown in (a), (b), (c) and (d) respectively.

The most significant climatic change feature that has been recorded in South Africa has been the warming of the interior of the country. Over the past century, temperatures in the South African interior have increased by 2°C in winter and spring (Figure 4) compared to a global average of 0.8°C. In the Southern Cape, this phenomenon has resulted in maximum temperatures increasing by 0.8°C to 1.2°C over the last century. Climate models predict this warming trend to continue over the next 40 years, with a further 1.2°C increase in maximum winter temperature expected by 2040 (Figure 5).

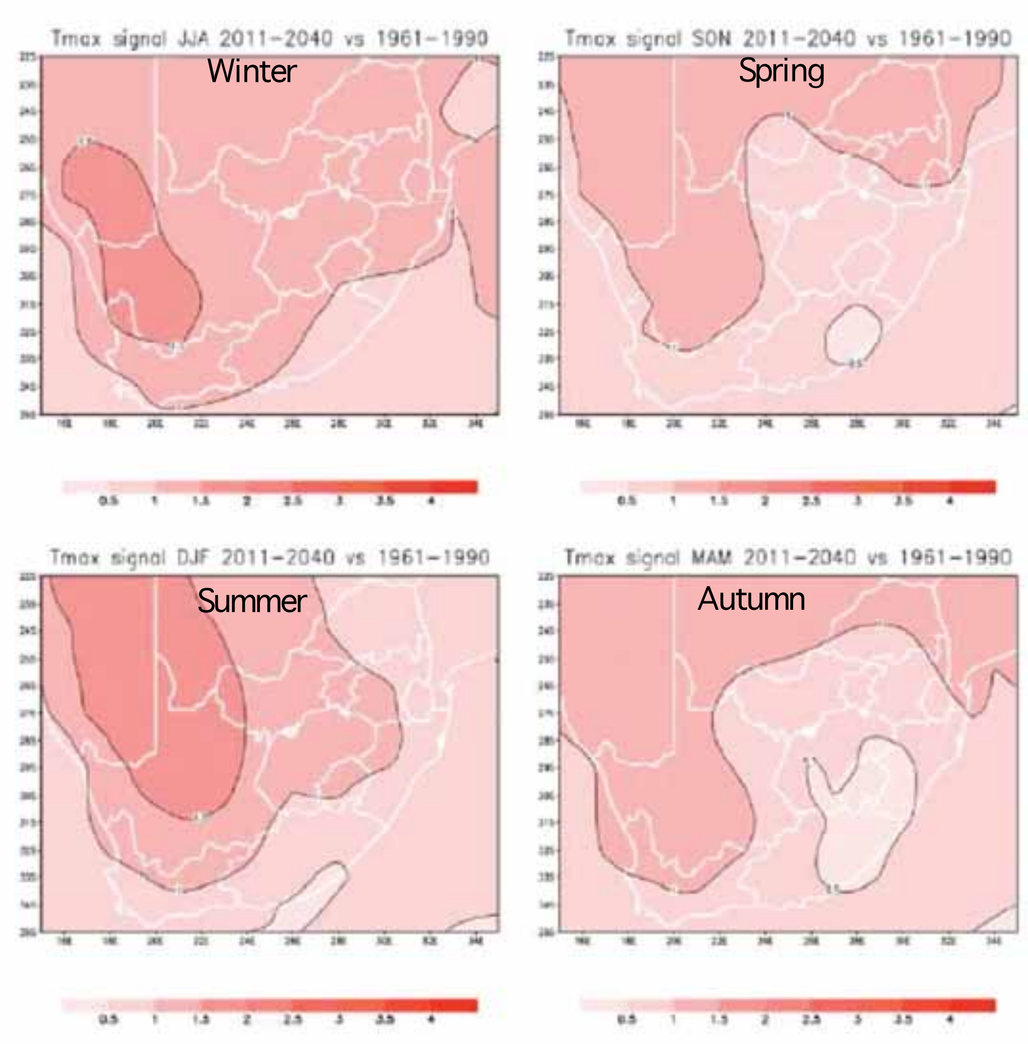


Figure 5: Projected rise in seasonal maximum temperature over southern Africa. The seasonal months of winter (June, July, August), spring (September, October, November), summer (December, January, February) and autumn (March, April, May) are shown in (a), (b), (c) and (d) respectively.

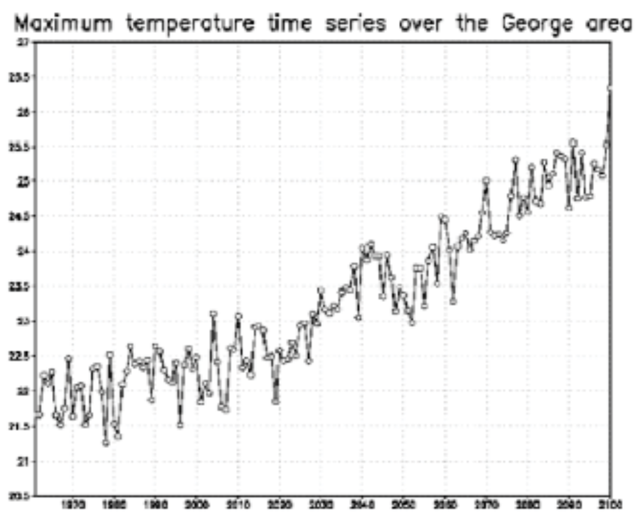


Figure 6: Projected rise in maximum annual temperature over the George Area.

Annual maximum temperature is also expected to continue to rise significantly over the next 50 to 100 years (Figure 6).

The picture for rainfall in the Southern Cape is less clear. This is largely because the study area is located between the two dominant rainfall regions in South Africa; the winter rainfall region in the west – which is predicted to become drier; and the summer rainfall region to the east and interior - which is predicted to become wetter but with more sporadic rainfall.

Historic long-term rainfall data show a slight reduction in rainfall over the period 1950 to 2000 (Figure 7). Different future climate projection models do not provide a cohesive story, however there seems to be the highest level of agreement around a projection that the area could continue to become slightly drier into the future, with up to 10% further reduction in rainfall over the next 40 years.

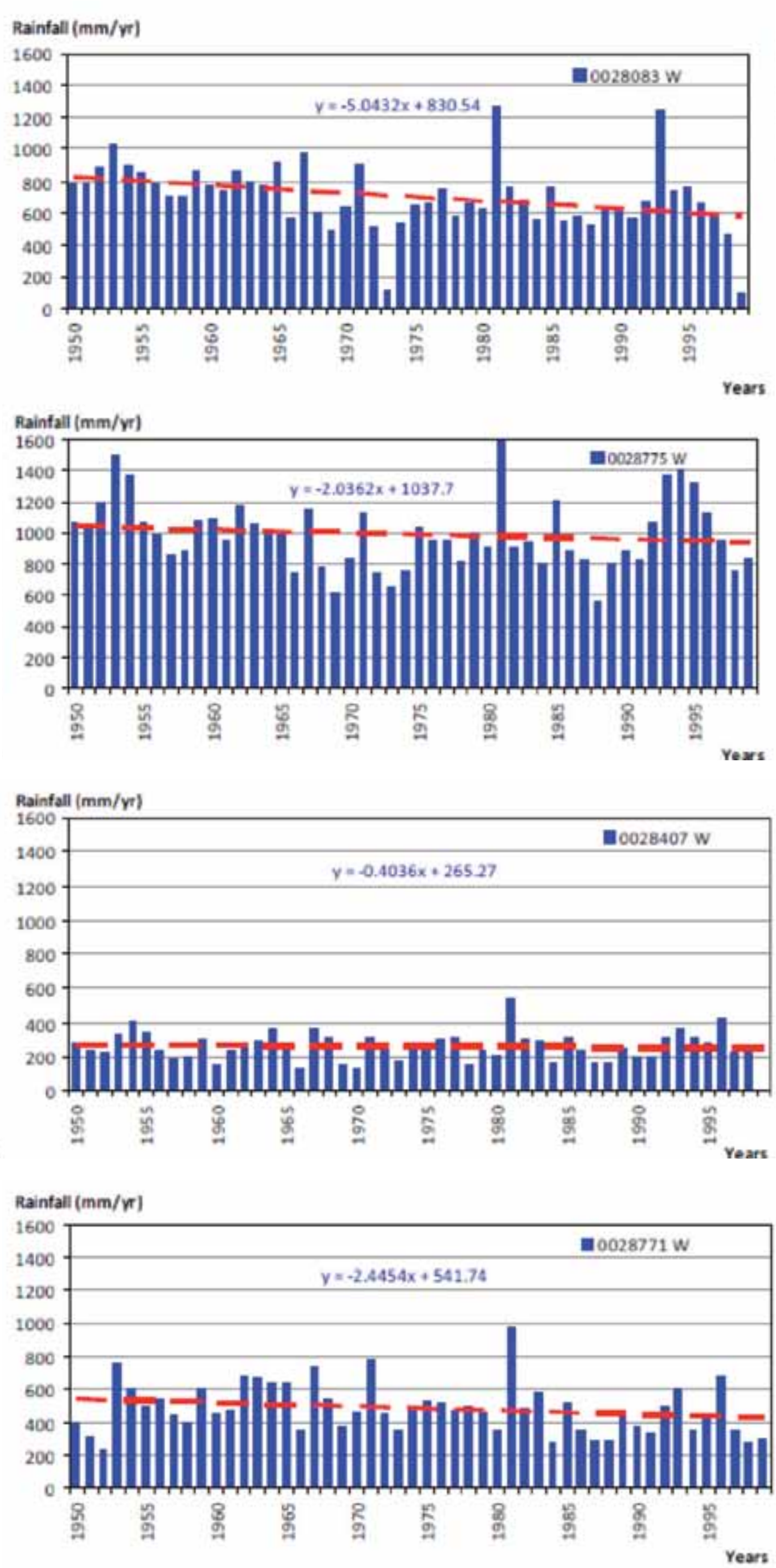


Figure 7: Long term rainfall data for rain gauges within close range of the Waboomskraal and Herold nested catchments.

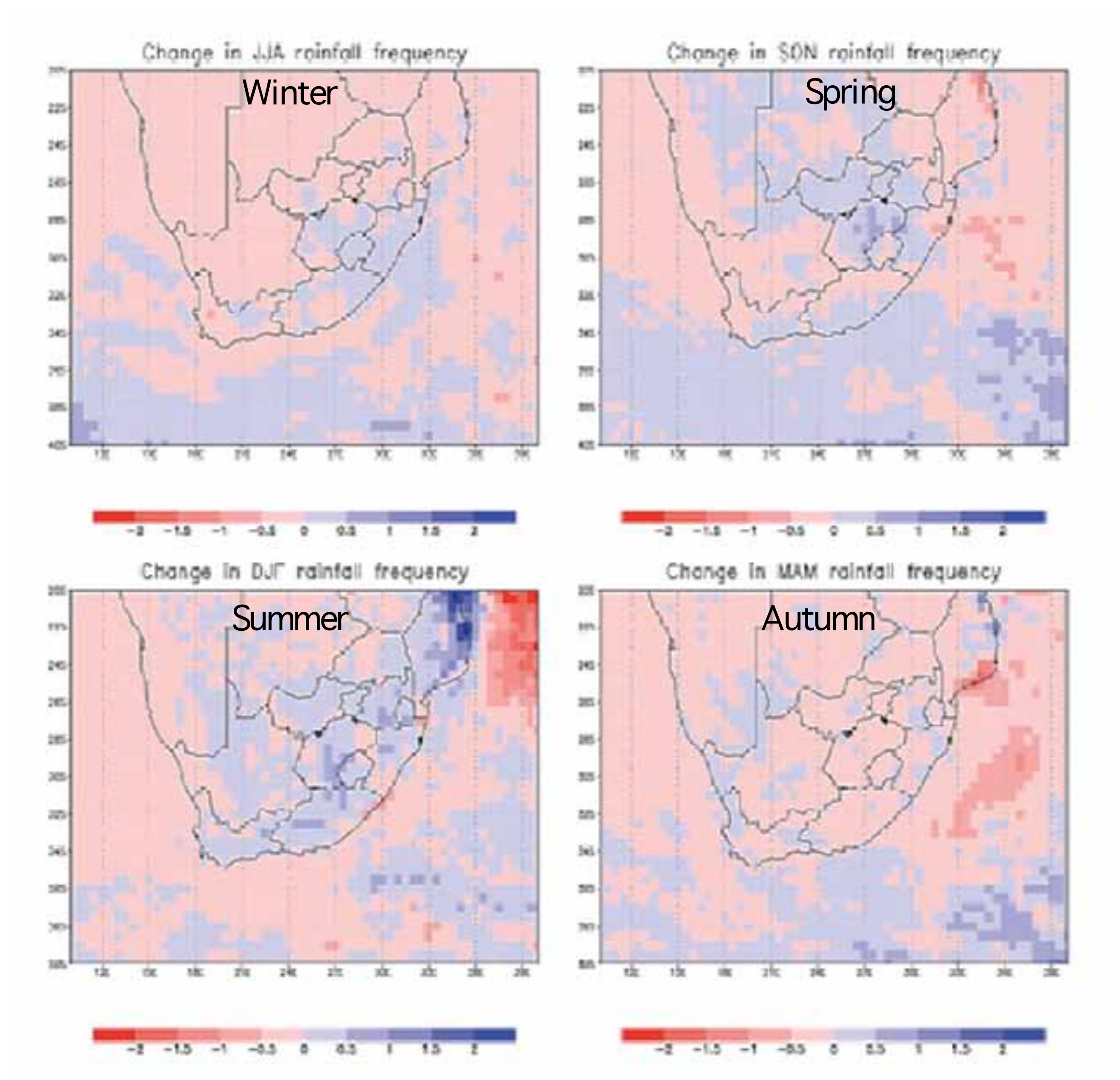


Figure 8: Projected change in the frequency of intense rainfall events over southern Africa. The seasonal months of winter (June, July, August), spring (September, October, November), summer (December, January, February) and autumn (March, April, May) are shown in (a), (b), (c) and (d) respectively.

Interestingly, the projected frequency of intense rainfall events (> 25mm in 24 hours) is predicted to increase in spring and summer (Figure 8). This could have an impact on erosion, sedimentation of dams and flood damage. The

Hydrological system

The SAB Hop farms are located in the Olifants Sub-Area within the Gouritz Water Management Area (WMA) (Figure 1). Demand currently exceeds assured supply in the Gouritz WMA by 64 Mm^3, with this is predicted to at least double by 2025 (Figure 9). The Olifants Sub-Area is also currently experiencing a water deficit of 3 Mm^3 with few options for closing this gap. The 'base' scenario predicts this deficit to grow to 4 Mm^3 per annum by 2025, while the 'high' scenario predicts the deficit to grow to 12 Mm^3 per year in the Olifants Sub-Area.

Rainfall in the Waboomskraal and Herold nested catchments is mostly orographic (associated with mountains), resulting from frontal rain clouds becoming trapped on the coastal side of the Outeniqua Mountain. This phenomenon results in a very strong rainfall gradient from about 1000 mm in the mountainous areas in the South (where the hop farms are located) to around 200 mm in the interior. The hop farms are located on the mountain slopes and experience a rainfall gradient of around 800 mm to 600 mm.

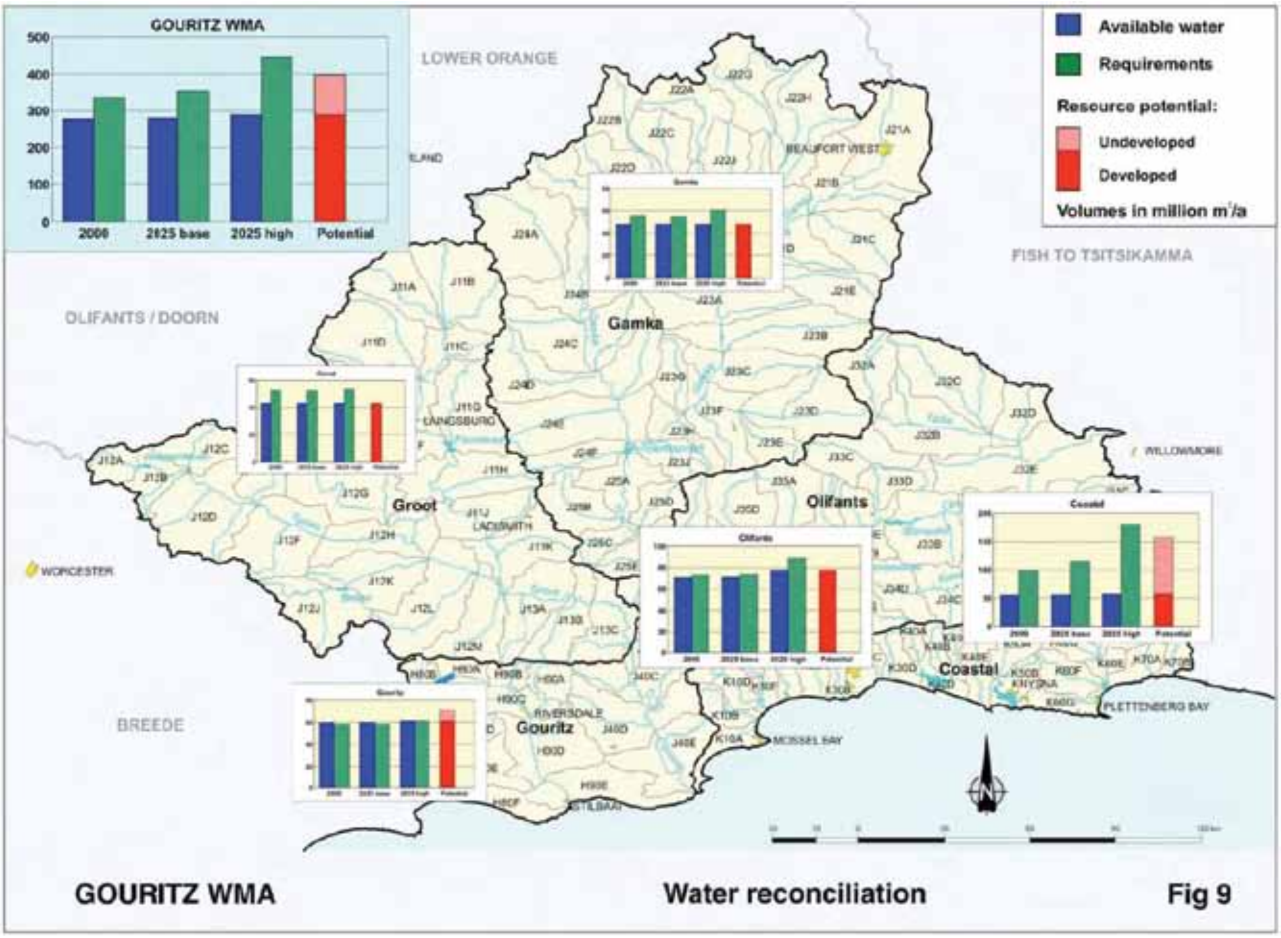


Figure 9: Water reconciliation in the Gouritz WMA (Basson & Rossouw 2003).

Surface water

Surface water in both the nested catchments is highly affected by Mean Annual Evaporation (MAE) which is around 1,600 mm or some four times higher than Mean Annual Precipitation (MAP). As a result, surface streams downstream of the hop farms flow sporadically, with surface flows only recorded about 50-70% of the time at flow gauges.

Mean Annual Runoff (MAR) in the area is around 14.5 million m^3 and Environmental Water Requirements (water required to sustain ecosystem functioning) are assessed to be about 15% of MAR (Reinman & Blake 2010).

Groundwater

The hop farms are located in the high rainfall recharge zone of the Table Mountain Group (TMG) Aquifer, which is recorded as having a fractured permeability of 0.5 to 2 Litres per second (DWAF 2006).

Groundwater moves northwards along discreet fracture zones into the centre of the Klein Karoo Basin. The large storage to recharge ratio of this aquifer means that this resource is protected against annual variation in rainfall. However, on-going water deficits in the Olifants Sub-Area (Figure 9) have led to plans to abstract significant volumes of water from the Table Mountain Group Aquifer just south of Oudtshoorn as part of the Deep Artesian Groundwater Exploration for Oudtshoorn Municipal Supply (DAGEOS) project. An assessment by Department of Water Affairs (DWA) indicates that 19 million m^3 could be abstracted from the deep confined TMG aquifer provided Resource Quality Objectives (RQOs) of unimpacted water levels and groundwater gradients are maintained. Currently, the Oudtshoorn Municipality have applied to abstract around 11 million m^3.

As this is a fractured aquifer, the exact hydrogeological connection between the DAGEOS abstraction and groundwater resources at the hop farms remains unclear. However, farm boreholes in the Waboomskraal area appear to be on the same NW-SE trending structure on which the DAGEOS test borehole is located, increasing the probability of a hydrogeological connection.

The Ecological System

Within the Gouritz Water Management Area, 49% of rivers are classified as being in a natural state, 34% moderately transformed and 17% heavily transformed. As can be expected larger rivers have been disproportionately modified due to their economic importance. However, it is important to note that healthy tributaries are critical for maintaining the functionality of these hardworking and modified mainstem rivers. The Klip and Doring tributaries that drain the Waboomskraal and Herold nested catchments respectively, have been modelled as being in a modified condition and both enter the Olifants mainstem river, which is classified as heavily modified. The link between groundwater health and river health should also be emphasised as these rivers are predominantly fed by base flows of groundwater during dry periods.

The hop farm nested catchments are located within important ecological corridors identified by the Gouritz Initiative to guide biodiversity and land-use planning. These areas were identified on the basis of promoting ecological integrity, connectivity and ecosystem-based adaptation to climate change.

Complementary biodiversity plans reveal that a number of 'Critical Biodiversity Areas' and 'Ecological Support Areas' are located on private land (owned by SAB or private hop growers) within these nested catchments (Figure 10).

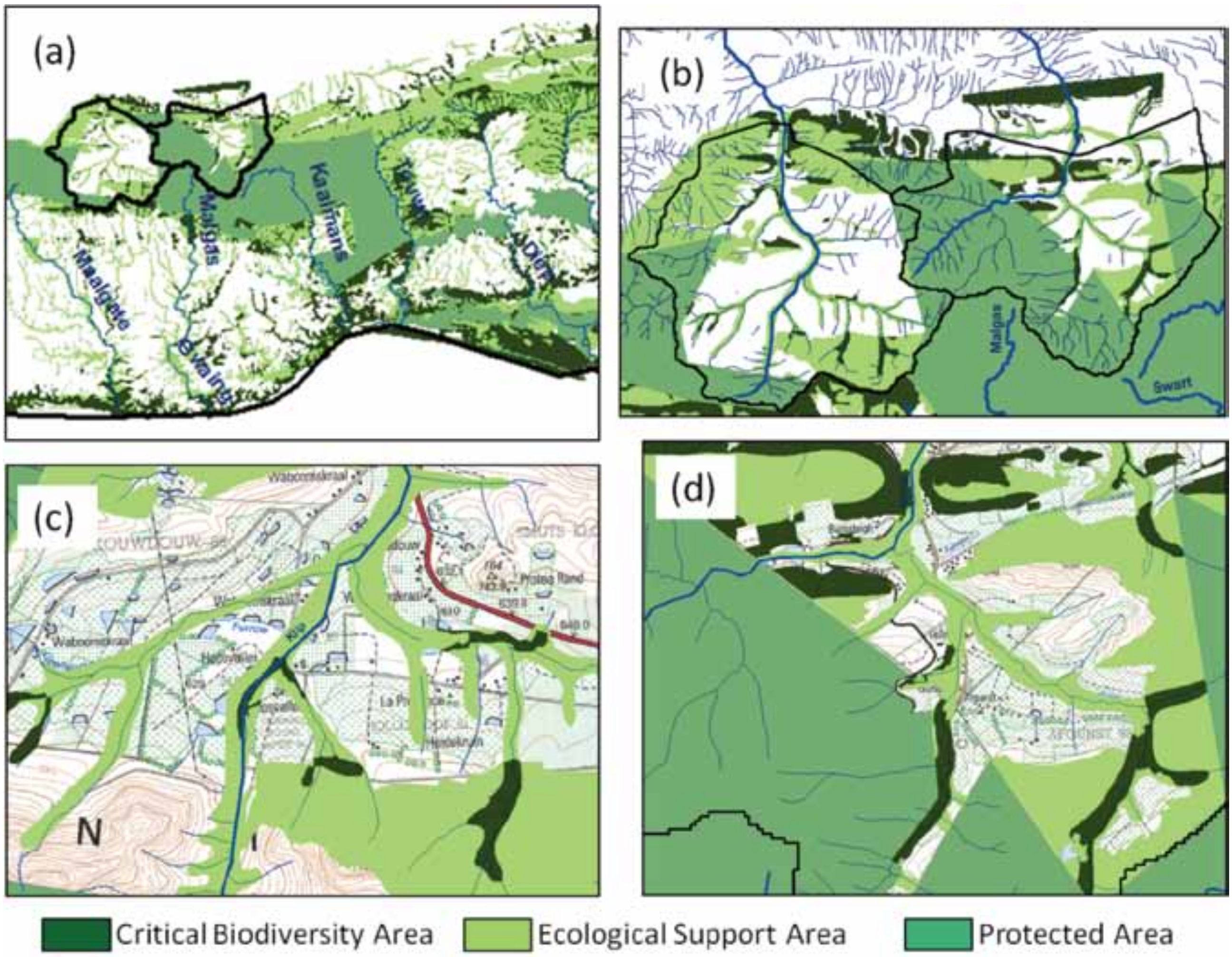


Figure 10: Critical Biodiversity Areas and Ecological Support Areas identified in the biodiversity plan for the Garden Route Initiative showing: (a) a portion of the Garden Route within which the Waboomskraal and Herold catchments are situated, (b) a close-up of the Waboomskraal and Herold catchments, (c) a close-up of the Heidekruin farm in the Waboomskraal catchment, and (d) a close-up of the Afgunst and Burnsleigh farms in the Herold catchment.

One of the greatest threats to ecological integrity and water resources in this area is the spread of invasive alien trees, which reduce water availability became they utilise more water than indigenous vegetation. In the Waboomskraal and Herold catchment the predominant invasive species are hakea (Hakea sericea), pine (Pinus spp.) and black wattle (Acacia mearnsii) (Table 1).

These species together cover 2,800 condensed hectares in the two catchments (2,200 ha in Waboomskraal and 600 ha in Herold) (Figure 11).

Even when water use estimates for these trees have been reduced for these drier climates, it is estimated that these trees could be using as much as 3,000,000m^3 of water per annum in these nested catchments (2,300,000m^3 in Waboomskraal and 700,000m^3 in Herold).

	% Condensed area* made up by each species	
Species	Waboomskraal	Herold
Hakea sericea	47	40
Pinus spp	37	29
Acacia mearnsii	15	30
Rosa rubiginosa	< 1	-
Eucalyptus spp	< 1	1
Acacia melanoxylon	< 1	< 1
Populus spp	< 1	-

**The area of infestation expressed at 100% density, e.g. 100 ha at 50% density is equivalent to 50 ha at 100% density*

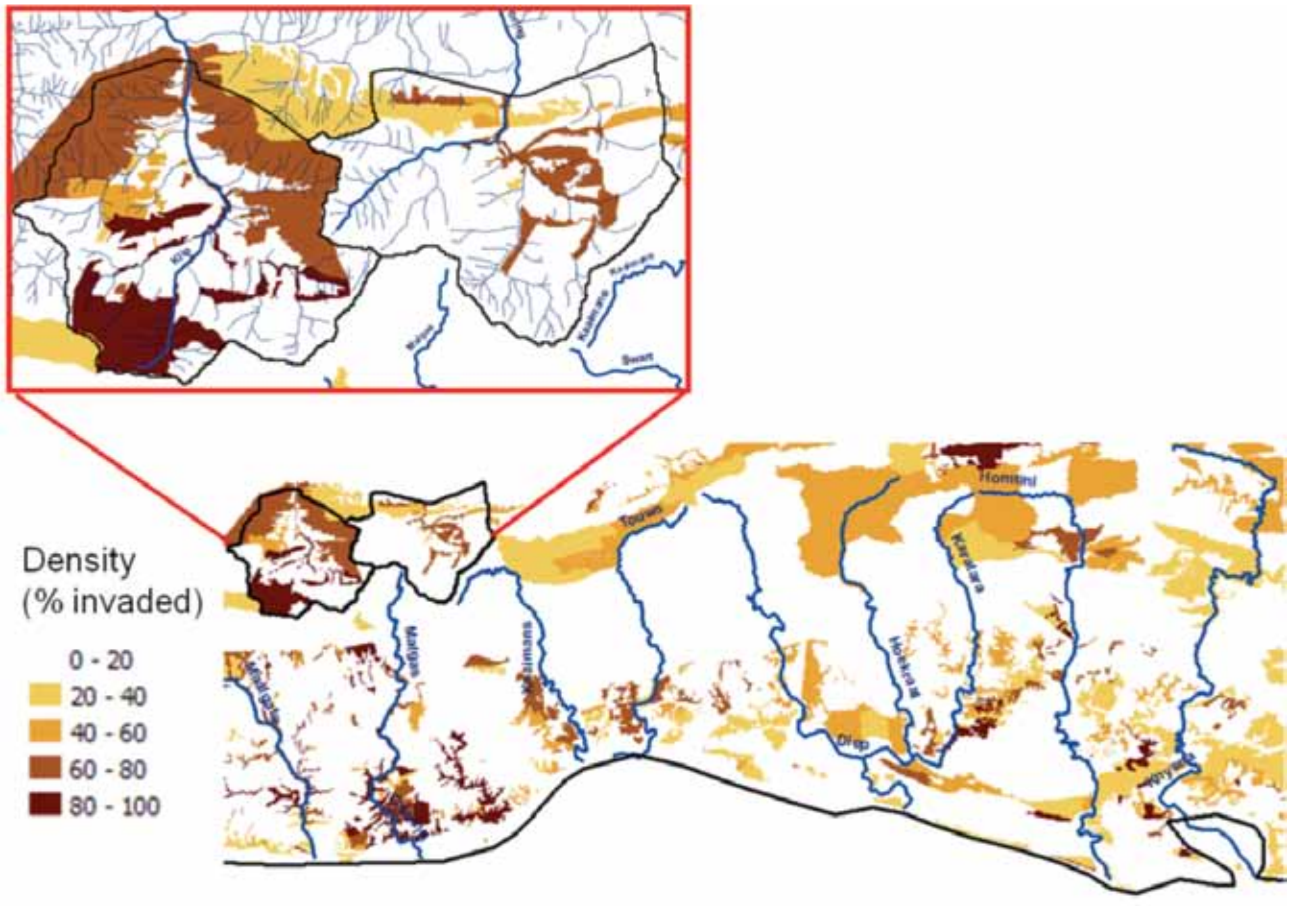


Figure 11: Extent of invasive alien plant infestation in the Waboomskraal and Herold catchments. Data are from the Garden Route Initiative (Vromans et al 2010).

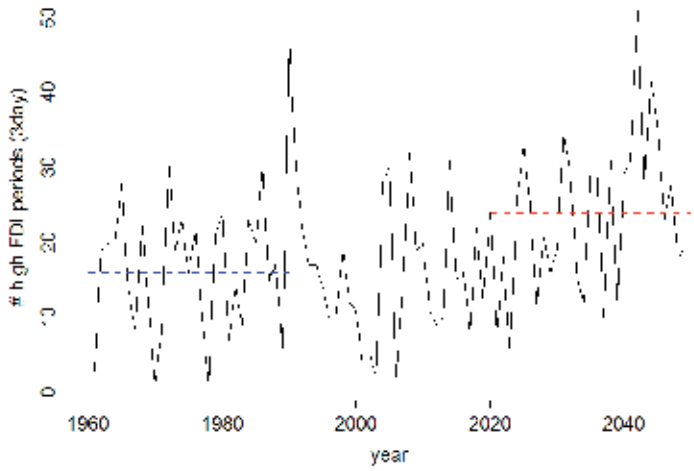


Figure 12: Number of High Fire Danger Index (FDI) weather periods projected to 2050 for the Eden District.

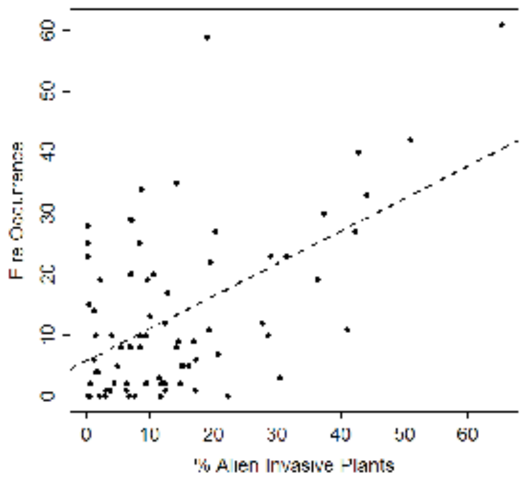


Figure 13: The relationship between occurrence of significant fires and density of invasive alien trees in the Eden District.

Fire is another ecological process that affects both ecological integrity as well as hydrological processes. Frequent and intense fires will increase risks of erosion and sedimentation of dams. The hops farms are located in an area of moderate fire frequency. However, recent decades have seen a significant increase in the frequency and size of winter fires in this area (presumably linked to increased winter ambient temperatures). This trend is predicted to increase into the future with an increase in the number of high fire risk days by 50% (Figure 12). In modelling key drivers of fire risk, density of invasive alien trees was the greatest predictor of the occurrence of significant fires (Figure 13).

The Socio-economic System

The main driver for competition for water will come from the municipality of Oudtshoorn. The current value of the Oudtshoorn economy is around R1.18 billion and has experienced an annual growth rate of around 3.6%. This has been mainly driven by growth in the construction industry which nearly doubled between 2001 and 2007. Despite this, the population has decreased by ca. 1% per annum from ca. 84,000 in 2001 to ca. 79,000 in 2007. The town of Dysselsdorp, from which seasonal labour for the hop farms is drawn, makes up about 15% of this with almost 12,000 residents.

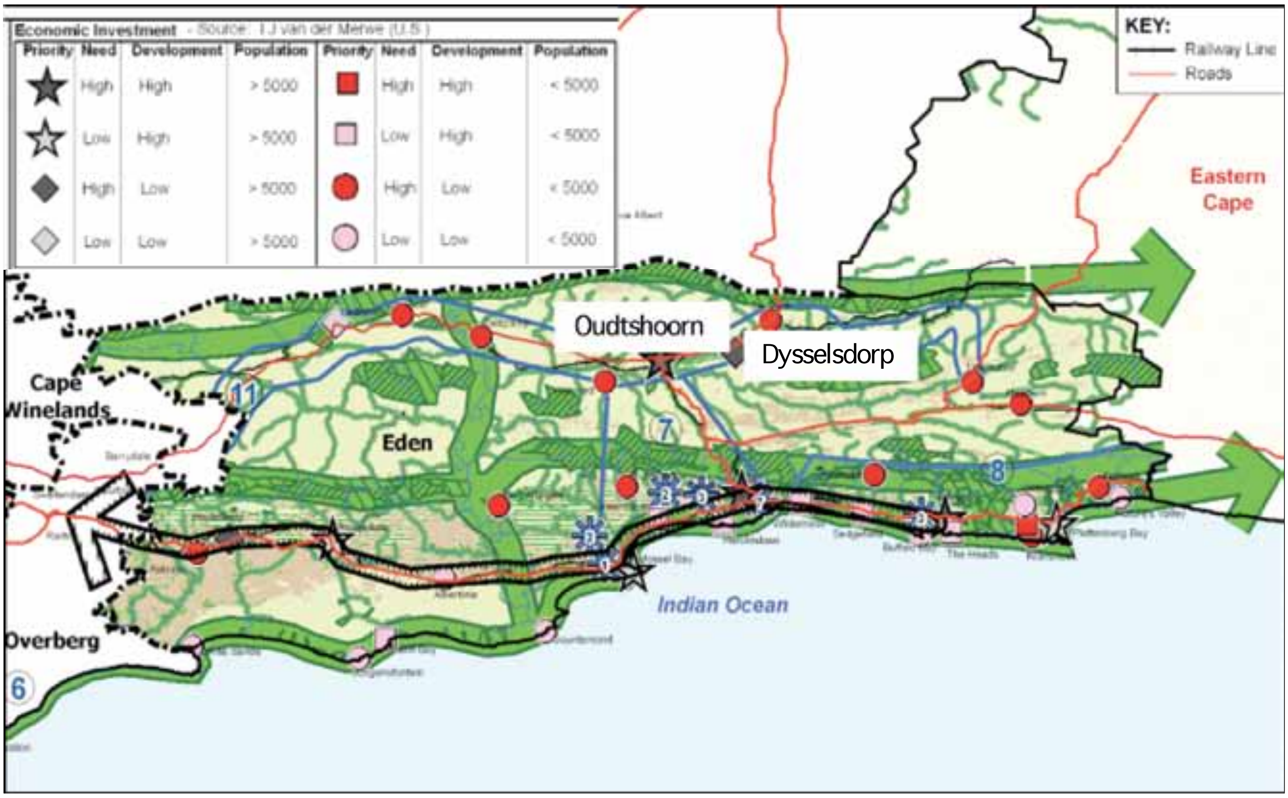


Figure 14: The Development Growth Strategy for Eden District Municipality identifying economic investment opportunities.

Extreme poverty in the Oudtshoorn area seems to be getting worse in the area with 40% of residents earning no income. There is heavy dependency on social grants. The Provincial Development Growth Strategy ranks both Oudtshoorn and Dysselsdorp as areas of great developmental need, however, Oudtshoorn is also ranked with high potential, while potential in Dysselsdorp is ranked as low (Figure 14). Water scarcity is identified as a major constraint to economic development. Despite this, Dysselsdorp has been selected as a pilot site for Comprehensive Rural Development Programme for the Western Cape. So far, R66 million has been pledged for investment from the provincial government for both social and economic development. Although just over half of this sum (R36 million) is earmarked for land restitution settlements, the programme is also seeking to build jobs through the Expanded Public Works Programme and increase the number of households with water harvesting technologies such as tanks and permaculture.

3. Integrated Systems View for Risk Identification

Ultimately the different systems views presented in the Situational Assessment are inter-related in a single integrated, dynamic system. In order to identify the major ultimate drivers of water risk to SAB Hop farms, a simplified conceptual model of this integrated system was developed (Figure 15).

Using this model and information presented in the Situational Assessment it was decided there are three major drivers of water risk to SAB hop production:

1. **Climate change** impacts on water availability mainly through the effects of changes in temperature, and to a lesser extent rainfall.
2. Loss of water through the spread of **water-intensive invasive alien trees.**
3. **Competition for water** from urban development in the Oudtshoorn municipal area.

All other risks were regarded to be closely related or intermediate drivers of risk. In other words, they were not the ultimate cause of the risk, but rather a means through which the risk was expressed. For example, ineffective water institutions are only a risk because there is ultimately competition for limited water resources.

The conceptual model (Figure 15) was used to understand how these ultimate drivers of water risk will drive risk and impacts throughout the system. Scenarios of future change were developed for each of these risks to understand the nature of the risk and its impacts over time at a more detailed level.

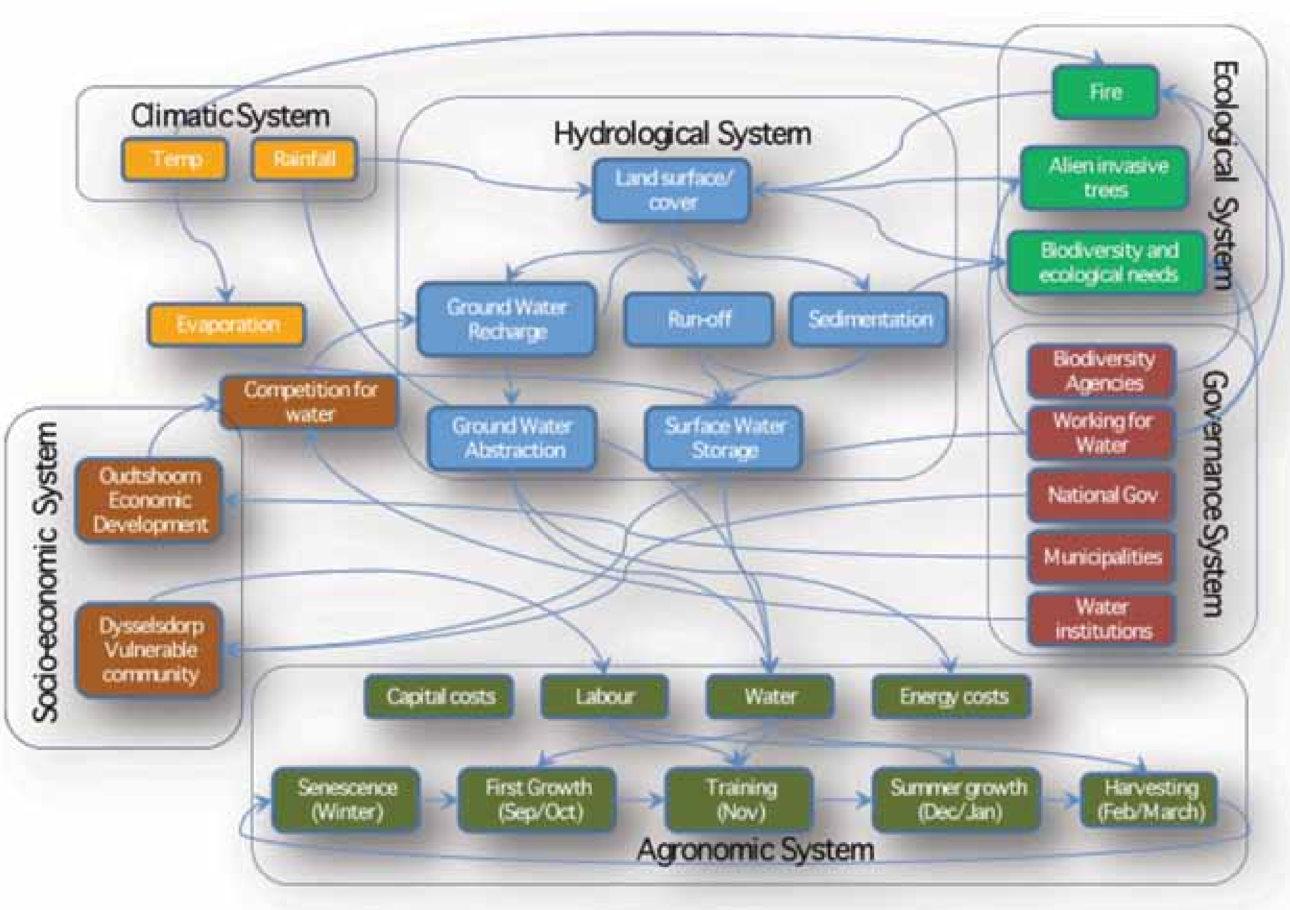


Figure 15: A simplified integrated conceptual model of the water risk to SAB hop production.

4. Future scenarios of change for major drivers of risk

Overall, climate change impacts increase the pressure on water resources, cause higher temperatures and increase the risks of extreme events such as drought, floods and fire. These impacts increase the risks faced by hops farming in this area, but the risks can be decreased by clearing alien vegetation, and changes for improved water monitoring and water use management made on the farms. This study has not identified whether the cumulative risks posed by climate change and invasive alien trees mean that hops production is no longer viable in the George area. In order to conclude this fairly, one would need to compare the risks posed in other hops production areas (e.g. risks posed by changes in climate and water quality).

Scenario 1: Climate Change

Temperature

The most significant climate change signal for this area is an increase in air temperatures. More detailed analysis of downscaled climate projections between 1960 and 2050 indicate that we can expect average maximum temperatures to increase by 0.7°C over the hop growing season (September to March) and average minimum temperatures to increase by 0.8°C over the same period. These temperature increases could lead to an increase in plant and soil evaporation losses of 6mm per month in the winter and up to 9mm per month in the summer. To counter these losses, farmers would need to apply at least 6mm more irrigation (60m^3 per hectare per month) for the five month period September to February. This translates to an additional 144,900m^3 of irrigated water per year for the industry. As surface water storage capacity is already currently oversubscribed, this additional water will need to be accessed from groundwater resources. Given that the average cost of groundwater (including all operating, maintenance and depreciation costs) is around R6 per m^3, this could translate to an increase cost of around R869,400 per year for the industry. However, energy costs are estimated to more than double within the next 20 years (Department of Energy 2010). A projected 2.5 times increase in energy will increase the average costs of groundwater to around R7 per m^3, increasing total costs to R1,014,300 per year.

Current Mean Annual Evaporation (MAE) for this area is 1,600 mm, which leads to around 25% annual evaporation loss from dams per year (Conway pers comm), or 250,000m^3 on a total storage capacity of ca. 1,000,000m^3. Initial calculations of the impact of future temperature increases on evaporation from surface storage dams indicates up to 3% increase in evaporation, or an increased loss of 30,000m^3.

Other impacts of projected temperature changes will include a 50% increase in the risk of the occurrence of significant fires. High frequency of fires will increase erosion risks and worsen the sedimentation of already shallow farm dams.

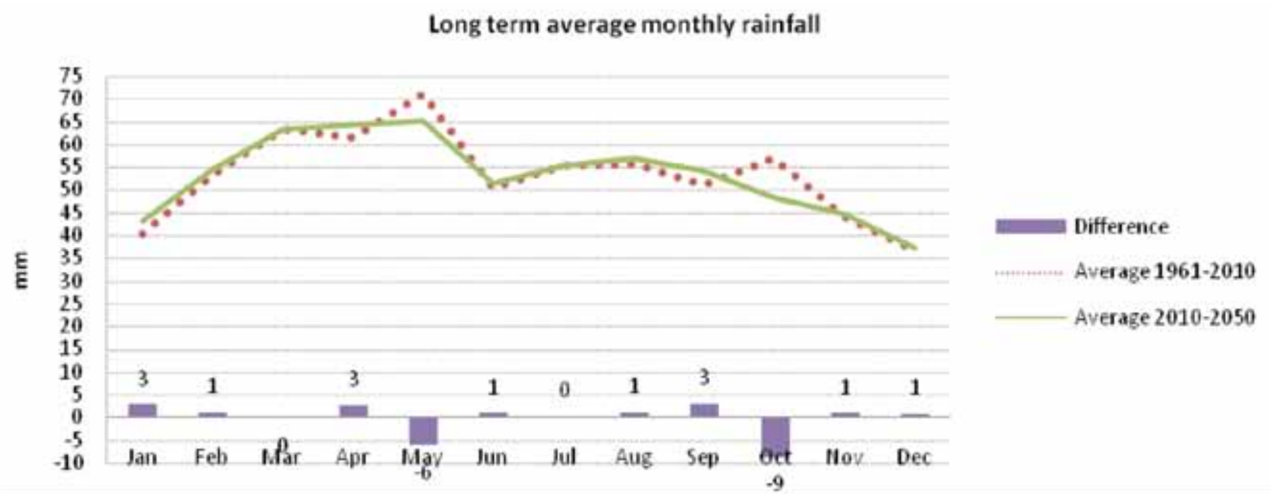


Figure 16: Long term average monthly rainfall 1961-2010 vs 2010 – 2050

Rainfall

The 1960 to 2050 climate change projection for rainfall is less clear. Different downscaled models give different values of changing rainfall, but all indicate a decline for the area on an annual basis, with a possible increase in extreme events in summer and spring by 2050. More detailed monthly analyses indicate that the decrease in rainfall would be most significant for hops growers in the months of May (6 mm) and October (9 mm) (Figure 16).

A decrease of 9mm rainfall in October will require farmers to irrigate an extra 90m^3 per hectare for the month, or 43,470m^3 at an industry level. As this additional water is likely to be pumped from groundwater, this will translate to an increased cost of R260,820 per year at an industry level at current energy prices.

In total, changes to climatic conditions are likely to increase the water requirements for farmers by 218,370m^3 on average. At a projected future costs of accessing this water from groundwater resources of R7 per m^3, this is likely to affect total production cost at an industry level by R1,528,590.

Scenario 2: Spread of Invasive Alien Plants

A Pitmann model was used to estimate the impact of invasive alien trees on Mean Annual Runoff (MAR). The current extent of invasive alien trees in the Waboomskraal nested catchment is estimated to reduce the MAR in this catchment by 20% or 870,000m^3, and in the Herold catchment by 13% or 800,000m^3. If left unchecked (and using an average spread rate of 5% per year) the

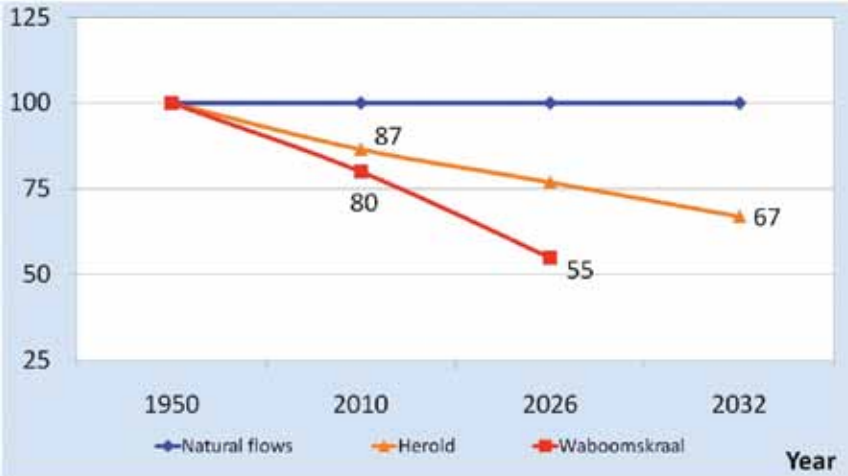


Figure 17: Predicted changes in Mean Annual Runoff (MAR) caused by the spread of invasive alien plants over time in the two nested catchments. The Y-axis shows % of Natural MAR.

Waboomskraal nested catchment could reach full potential invasion by 2026. This will reduce the MAR by 45% or 2,450,000m^3 (Figure 17). The Herold catchment is predicted to reach full potential invasion by 2032 if left unchecked, reducing the MAR in this catchment by 33% or 2,050,000m^3. In totality, if invasive alien trees are left unchecked MAR will be reduced by 41% or 4,500,000m^3 in the two catchments.

Given that the total surface storage capacity is about 1,015,000m^3 (455,000m^3 in Waboomskraal and 560,000m^3 in Herold), the registered groundwater abstraction is around 200,000m^3, and the total irrigation requirement is about 2,200,000m^3; this means that the dams need to fill at least twice during a year to provide for irrigation requirements from surface water (i.e. 2,030,000m^3).

A decrease of 45% in MAR in the Waboomskraal catchment (as predicted in the full potential invasion scenario) could therefore mean a decrease in surface water availability by 409,500m^3 (455,000m^3 x 2 x 41%). In the Herold catchment, a 33% decrease in MAR could result in a decrease in surface water availability of 369,600m^3 (560,000m^3 x 2 x 33%). In totality a full potential invasion of invasive alien trees would therefore reduce surface water yield to the major hop farm dams by 779,100m^3 per year. Assuming that this 'lost water' was able to be replaced by pumping groundwater, the economic impact on the industry (at R6 per m^3) would be around R4,674,600 per annum. Predicted future increases in energy prices could see this cost escalate to R5,453,700 per annum.

Scenario 3: Water Competition Scenario

The Olifants Sub-Area currently experiences a water shortage of 3 million m^3 (Water Requirements = 74 million m^3 and Water Yield = 71 million m^3). Even without the impact of invasive alien plants and climate change which will significantly reduce water resources, the existing deficit is projected to increase to 4 million m^3 per annum by 2025 as per the 'base' scenario for this area (Department of Water Affairs and Forestry, 2004b), driven by an expected increase in urban demand. The Internal Strategic Perspective (ISP) of the Department of Water Affairs also presents a 'high demand' scenario, which predicts a water deficit of 12 million m^3 per annum (also due an increase in urban demand). Given that the economy of Oudtshoorn continues to grow at around 3-4%, despite a 1% per year population decline between 2001 and 2008, the 'high demand' scenario as described in the ISP is unlikely. A more conservative scenario was therefore adopted for this study, where a 'low demand' scenario (of the deficit growing to 4 million m^3 by 2025) and a 'middle-road' demand scenario (of the deficit growing to 8 million m^3 per annum by 2025) were considered.

With virtually no additional options to augment water supplies from surface water, additional water will need to be sourced from groundwater resources or re-allocation of water-use rights from agriculture irrigation (which is the predominant user at 84%).

Within the Olifants Sub-Area there are 7,874 ha under irrigation. A 'low-demand' scenario without further augmentation of water supply would therefore require about 508m^3 of water per hectare being re-allocated to urban use, in order to reconcile the deficit of 4 million m^3. This would effectively reduce the irrigation water allocation for hop farms by 245,364m^3. Without improvements to irrigation efficiency and assuming farmers will not apply deficit irrigation, this would effectively remove 47 ha of hops from production (almost 10%).

For a 'middle-road' scenario, without any further augmentation of water supply from groundwater sources, about 1,016m^3 of water per hectare would need to be re-allocated from agricultural irrigation to urban use, in order to reconcile the deficit of 8 million m^3. This would effectively reduce the irrigation water allocation for hop farm operations by 490,728m^3. Without improvements to irrigation efficiency and assuming farmers will not apply deficit irrigation, this would effectively remove 93 ha of hops from production (almost 20%).

Future groundwater options to address increases in urban demand include the Deep Artesian Groundwater Exploration for Oudtshoorn Municipal Supply (DAGEOS) project. Augmentation of Oudtshoorn's water supply through the DAGEOS project is planned to deliver an additional 11 million m^3 per year. This will effectively cater for the 'middle-road' growth scenario for Oudtshoorn and probably avert any re-allocation of agriculture water-use rights. However, this project has its own risks to hop farmers, in that the groundwater resources that are increasingly being accessed by hop farmers may be hydrologically connected to the deep water aquifer being accessed by the DAGEOS project. This is likely to have a greater impact on the Waboomskraal nested catchment, which appears to be on the same NW-SE trending structure. The extent of the connection and potential impacts are impossible to estimate at present, however, it is strongly recommended that hop farmers start monitoring and collating groundwater data from their boreholes in order to ascertain baseline and potential impact information in a more scientific manner.

Finally, while the bulk of the hop farms are hydrologically more connected to water reconciliation in the Olifants Sub-Area, the more critical water deficit of 43 million m^3 (at 98% assurance of supply) in the coastal region should not go unmentioned (DWAF 2004b). This huge deficit may lead to coastal municipalities exploring the development of well-fields in the high groundwater yield areas of the Outeniqua Mountains. This could directly impact groundwater access for hop farmers. Again, this illustrates the paramount importance of farmers starting to monitor and collate groundwater data on their hop farms.

Conclusions from Scenarios:

Climate impacts on farming operations in this area appear to be mainly manifested through changes in temperature. On average, economic impacts are expected to be fairly modest – in the range of R1.5 million per year at an industry level. The impacts of invasive alien trees are expected to be more severe. Without any intervention these trees are expected to spread to full invasion by 2032 and impact the Mean Annual Runoff by 41% in the two catchments. This could reduce annual surface water yield to hop farm dams by up to 780,000m^3, requiring R5.4 million per annum to recover this water from groundwater. Continued water deficits and competition for urban water needs from Oudthoorn could also have modest impacts on the hop farms through water allocation. This threat is likely to be averted through the access of a deepwater aquifer by the Oudtshoorn municipality under the DAGEOS scheme. However, this may pose a different threat through the DAGEOS scheme drawing down on groundwater being accessed by hop farmers. It is therefore vital that farmers start to monitor their groundwater resources.

5. Response Strategies

Based on the information presented in the scenario analyses, three major response strategies are proposed below. These initial proposals are intended to provide ideas and background on the way forward. It is not within the scope of this study to provide detailed costs at a farm scale, for instance for monitoring and improved water-use efficiency. However, an overview of the costing for invasive alien tree removal is provided at a catchment scale.

These responses are currently being considered by South African Hops Farms and the Water Futures Partnership and do not represent agreed plans or budgets.

Response Strategy 1: Catchment Rehabilitation and Stewardship

Objectives:

- Restore the natural hydrological and ecological functionality of the area, primarily through the removal of invasive alien trees; and
- Secure these hydrological and ecological services through engagement in formal biodiversity stewardship agreements.

Context:

The hydrological and ecological functionality of the Waboomskraal and Herold catchments is currently severely compromised, primarily through the invasion of water-intensive invasive alien trees which presently cover ca. 2,800 condensed hectares and are estimated to use about 3,000,000m^3 of water. These trees currently reduce Mean Annual Runoff by 15% or 1,670,000m^3. If left unchecked, these trees will reach maximum potential invasion by 2032 and reduce surface water yield by 41% or 4,500,000m^3. This could reduce surface water yield to hop farm dams by ca. 870,000m^3 per annum. If this 'lost' surface water was to be replaced by groundwater sources, it would add ca. R5.2 million to the production costs of hops at current energy costs. Predicted future increases in the price of energy will increase this cost significantly. This also does not take into account the impacts of invasive alien trees on groundwater recharge, which are more difficult to quantify.

These reductions in water availability should also be seen in the light of predicted increases in air temperature in this region, which will increase irrigation requirements by ca. 217,000m^3.

Other impacts of the spread of invasive alien trees include elevated frequency of significant fires linked to higher erosion levels and consequent sedimentation and shallowing of dams.

Intervention:

It is proposed that SAB considers playing a leadership role in developing a local co-ordinating structure with a comprehensive catchment rehabilitation and stewardship programme.

Scale and Costs:

A preliminary assessment of the costs for the clearing of 2,800 condensed hectares of invasive alien trees from these two catchments is around R39 million (at an estimated R14,000 per hectare, which is the average cost of initial clearing obtained from Working for Water). Structuring such an operation over an initial clearing period of 10 years (i.e. initial clearing of 280 ha per year), will result in a cost structure shown in Figure 18. The highest single annual cost will be R4.2 million in the 10th year of

Figure 18: Preliminary assessment of the annual cost structure for clearing 2,800 condensed hectares of invasive alien trees from the Waboomskraal and Herold nested catchments.

the programme. Thereafter, costs will taper off because all initial clearing operations have been completed, with only a few stands requiring follow-up treatment. These costs account for a 3% annual inflation rate.

A partnership with the National Wage Incentive Scheme through the Working for Water programme could yield a contribution in the region of R19 million (based on a contribution of R90 per day) to this programme. Given that corporate contributions would be tax deductible, a further 30% (corporate tax rate) of these costs could be written off against tax. This will result in balance of R14.2 million to be contributed over the 15 years of this programme (Figure 19). The maximum real annual corporate contribution would be around R1.7 million in year 10.

It is further estimated that up to 2,000 ha of private land, owned by SAB or contracted hop farms, could be committed to formal Biodiversity Stewardship Agreements. While a formal section 23 Nature Reserve commitment would offer the greatest tax benefits (with up to 10% of the value of the land qualifying for tax deduction per annum for 10 years), it is more likely that these areas would be better suited for Protected Environment status. This will still enable management costs to be tax deductible as well as benefit from more cohesive management with neighbouring CapeNature Nature Reserves. Protected Environment status helps to ensure continued funding streams because potential funders (e.g. National Wage Incentive Scheme) are provided with an assured security of land and its management – this, and the improved ecosystem service benefits, are often more important incentives than the tax incentive that can be derived. An additional benefit of Protected Environment status is that it demonstrates due diligence for the clearing of invasive alien plants on land, which is a legal obligation for all land owners in terms of the Conservation of Agricultural Resources Act (CARA).

Benefits:

Water:

This intervention will avert a situation where potentially up to 41% of the MAR in these two catchments could be lost by 2032. This will avert the loss of up to 800,000m^3 of surface water to hop farm dams per annum.

Economic:

The 800,000m^3 of surface water lost to a full potential invasion of alien trees, will cost the industry in the region of R5.2 million per annum to access from groundwater at current energy prices (prices are expected to double in the next five years). The economic benefit of clearing the invasive alien trees will thus be equal to the cost averted.

Employment and Rural Development:

This intervention could create in region of 200,000 employment days, or around 100 full jobs per year. If seasonal semi-skilled labour is used from Dysseldorp, this could bring greater financial security to up to 150 seasonal labourers. At an average of five dependents per employee, this intervention could benefit close to 900 people. This would make a positive contribution to the small rural town of Dysselsdorp, with only 12,000 residents.

Ecological Integrity:

Commitment of these areas to formal biodiversity stewardship agreements will make a significant contribution to the ecological integrity of this area. Not only will identified Critical Biodiversity Areas and

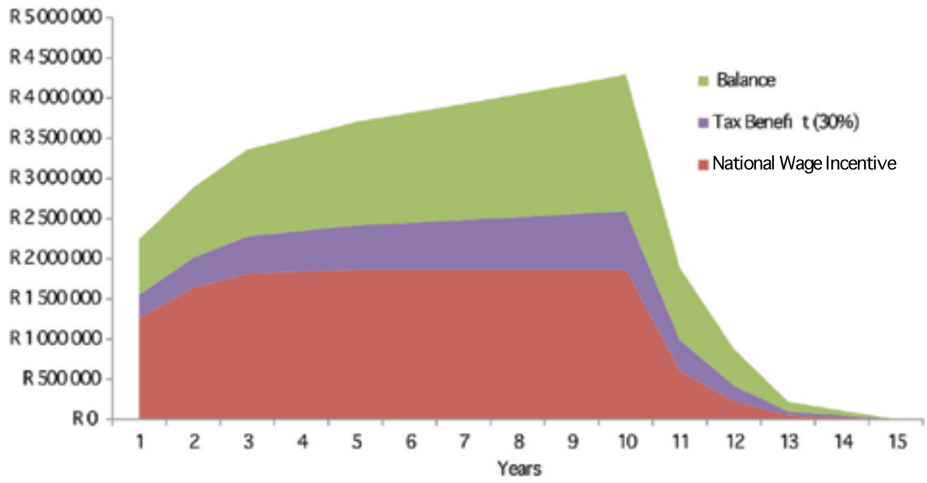


Figure 19: Potential contributions and balance of costs for the clearing of 2,800 condensed hectares of invasive alien trees in the Waboomskraal and Herold catchments.

Ecological Support Areas be secured but the contiguity of an important ecological corridor will also be secured.

Management benefits:

More coherent management with neighbouring Nature Reserves could yield cost benefits.

Reduction of other risks:

This intervention will reduce other risks such as fire, erosion, and sedimentation with subsequent shallowing of dams.

Implementing structure:

It is suggested that a local implementation structure is developed that can receive funds from multiple sources and co-ordinate a project of this scale over a 10 to 15 year period. The local Fire Protection Agency or Water User Association could be an appropriate body.

Response Strategy 2: Water Leadership in Farmers' Water Monitoring and the Establishment of Water User Institutions

Objectives:

- To lead a stakeholder monitoring programme focussed on groundwater resources and hydrology in the Waboomskraal and Herold catchments that can be used to understand the baseline state and potential future impacts on these resources.
- To play a leading role in the development of appropriate institutions to represent water stakeholders in this area.

Context:

Country-wide, and within the area covered in this study, few water resource users are adequately monitoring the resources they use or the volumes they are using. Monitoring water data, such as rainfall, groundwater levels, dam levels and rates of river flow, are essential to inform evidence-based decision making. These data show changes in available water resources brought about by climate change, abstraction or replenishment resulting from invasive alien tree clearing. Basic water resource monitoring at a farm-scale entails:

- establishing monitoring infrastructure;
- validated measurement;
- data storage; and
- understanding monitoring data and identifying key thresholds for action.

Farmers can conduct monitoring individually but can benefit from establishing a monitoring committee with respect to:

- sharing the costs of validating data;
- sharing the costs of a hydrologist/ geohydrologist interpreting data for them; and
- gaining a catchment and aquifer-scale understanding of how the larger water resource is responding to change.

The establishment and functioning of new water institutions such as Catchment Management Agencies and Water User Associations has taken place more slowly than envisaged at the time of their legislation in 1997 and 1998. Within the next six to 18 months the Department of Water Affairs and Oudtshoorn Municipality intend to facilitate the establishment of a monitoring committee for groundwater in the vicinity of the DAGEOS project. Within this same time period it is likely that the Breede Catchment Management Agency will be linked to the Gouritz Catchment

Management Agency, to establish a functioning twinned Catchment Management Agencies. Both the National Water Act (1998) and the Water Services Act (1997) rely on the participation of NGOs representing water stakeholders. Water User Associations are intended to replace the irrigation boards that represented the agricultural sector prior to 1998. The establishment of Water User Associations has also been slow and few are functioning in an effective manner to improve the sustainability of water management in their areas. There is an opportunity for SAB Hops farms to play a critical and catalytic role as leading water stakeholders in their catchments.

Figure 20: A data logger such as this Solinst logger is suspended in a borehole at a fixed depth to record changes in the groundwater level. This level should be verified with a dip meter. Data may be downloaded at the borehole directly onto a lap top, or it may be downloaded remotely and accessed via the internet.

Intervention:

It is proposed that SAB lead the establishment of a local water monitoring committee. This committee should include the WWF South Africa, government agencies and all the local hops farmers. It should monitor dam water levels, groundwater levels and some river flow in the upper catchments. The monitoring committee, assisted by water experts, should initially: assess which farmers will participate in monitoring, liaise with the Department of Water Affairs around access to the Department's local rainfall data, determine how the Department will verify monitoring data, design the monitoring network at a catchment scale within participating farms, and cost the monitoring network per farm. Data loggers (Figure 20) may be deployed in boreholes and secured in dams to take automated measurements at a pre-set time interval. They may be downloaded every few months by physically connecting the data logger to a laptop at the monitoring site. Or they may be connected to a telemetric system with remote download via a cell-phone or satellite systems. This data is available via the internet on a daily basis (Figure 21). The Department of Water Affairs are currently monitoring boreholes and weather stations in this area with a telemetric system and have offered their assistance in training farmers to use this system.

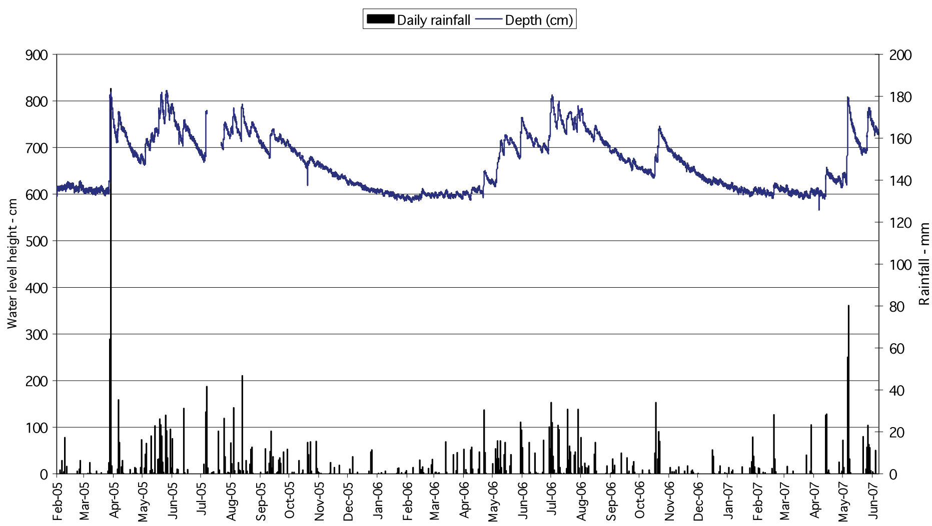


Figure 21: Water level data from a borehole in the Table Mountain Group aquifer (blue line) and daily rainfall events (black bars). This shows what the water level data will look like and typical responses in a TMG borehole to recharge events.

SAB would initially work closely with the farmers and the Department of Water Affairs to set up the water monitoring committee and ensure that sustainable processes for data collection and decision making are in place. This committee should form a core group for the DAGEOS monitoring committee and may later decide to form a Water User Association. It is recommended the feasibility of the monitoring committee be established first, before beginning a process to establish a WUA. However, the process of establishing a Water User Association is fairly complex (Figure 22).

Scale and Costs:

A process is on-going to establish a Table Mountain Group monitoring committee which is being facilitated by the Department of Water Affairs and the Oudtshoorn Municipality. SAB should coordinate the interest of the hops farmers and invest the time of a representative in this process. All of the supply farms should start monitoring groundwater levels on their farms, preferably in disused non-pumping boreholes, but possibly also in production holes. At least two data loggers per farm should be deployed with the guidance of WWF South Africa on

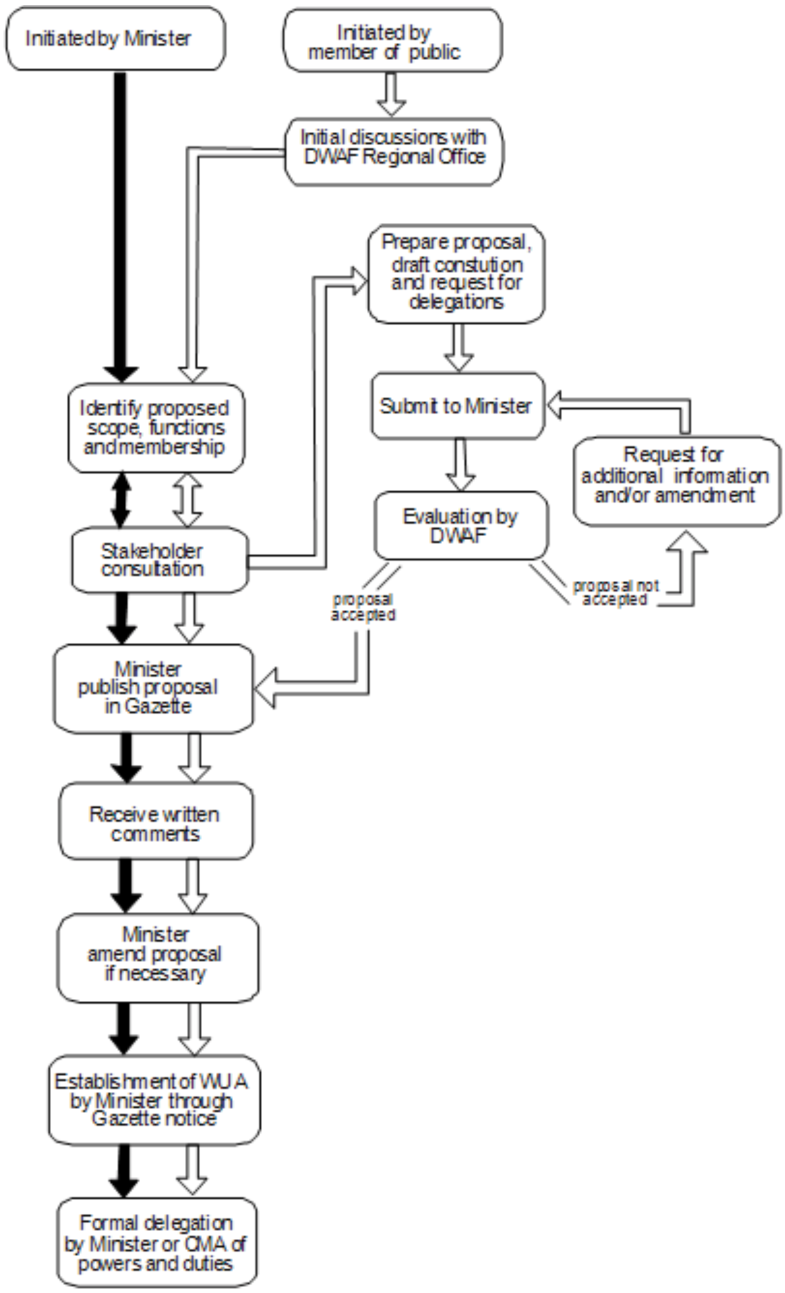


Figure 22: Establishment of a Water User Association (DWA CMA/WUA guide series).

positions, measurement frequency and borehole testing. The capital cost is approximately R5 000 per data logger.

The process of gathering data should be initiated in close consultation with the regional office of the Department of Water Affairs and, in particular, Information Systems and the National Groundwater Archive. There is currently no agreed protocol on the role and validation of Water User Association data, yet these data will form an essential part of future negotiations of water use and access, not only in these catchments, but country-wide.

If the monitoring committee decide to begin the process to establish a Water User Association, they will need to do this with other key water-users in the area with a common interest in protecting and maintaining sustainable access to local water resources. This will require coordination from SAB, active participation of the hops farmers and the professional services of a lawyer and facilitator.

Benefits:

Water:

It is very difficult to manage resources that we do not monitor. Currently the hops farmers have a very low level of confidence in the volumes of water they are using for irrigation. Improved understanding of how much groundwater is available, how groundwater responds to local and regional abstraction and rainfall, and how surface water flows fluctuate with climate and land-cover will be critical to future management of water resources and head-water catchments. Local monitoring is the first step to scientifically measuring water flows in the local landscape.

Economic:

The establishment of valid stakeholder institutions and collation of water data should be the first step to increasing the assurance of water supply for irrigation. Better relationships with fellow water users should promote improved water security in the catchment. Better quantification of water availability and use with objective data should also allow for improvements in efficiency of water use and consequent cost savings.

Employment and Rural Development:

This intervention will contribute towards ensuring the sustainability of rural employment in hops production in the area.

Ecological Integrity:

Water monitoring will protect resources from over-abstraction and the consequent ecological impacts of declining water levels.

Management benefits:

Collecting local data on the availability of groundwater and surface water resources will enable better planning for increased use in the future. Groundwater is the only resource that is envisaged to be available for increased use to offset higher irrigation requirements with increased temperatures, and to buffer for increased variability in surface supplies.

Reduction of other risks:

The risk of re-allocation of agricultural water to other users should be reduced by the establishment of an effective body to represent interests of the hops farmers and other agricultural users and employers in the area.

Implementing structure:

Establishing a monitoring committee should be the first step towards implementation. This will require the support and specialist input from SAB and WWF South Africa, as well as commitment from the local farmers. Relationships with the Department of Water Affairs, the Oudtshoorn Municipality (and other local government, including George) and the new Catchment Management Agency will be critical to the effective functioning of the monitoring committee.

Response Strategy 3: Farm-level Optimised Water Management

Objective:

To optimise water-use efficiency for hops production at the farm-level.

Context:

Optimisation of water-use efficiency implies maintaining the quality and yield of hops production, while improving irrigation practice to reduce water inputs. Each of the hops farms operates within climate specific terroirs, so different interventions will be appropriate at different farms. For example, the replacement of an overhead sprinkler system with an underground drip system would not necessarily be feasible at Burnsleigh, which experiences relatively warm temperatures during summer; however, this may be feasible at the cooler farms.

Increasing water-use efficiency should enable farmers to respond more effectively to water risks and periods of water shortage in the future. This response strategy recommends interventions that require a more scientific approach to water-use, which may require contracting specialist skills, such as irrigation engineers, to advise on site-specific options.

The first step in optimising water use should be to minimise unnecessary losses. Losses may occur from leaks within the irrigation infrastructure, sub-optimal dam storage, and over-irrigation. Each of these issues can be addressed with expert assessment and training of farm workers for operation and improved maintenance.

Interventions:

1. **On-going monitoring for leak detection.** Farm labourers should be trained in leak detection, including how to spot leaks from over-ground and under-ground sources, who should be notified, and how to fix and reduce leaks. Best practice should be established which should continue as part of the on-going management of each farm.

2. **Implementation of underground drip irrigation** at certain farms that are not exposed to the higher temperature regimes (Figure 23). This method of irrigation is more efficient, but does not have the additional benefit of cooling the plants during hot periods. Where cooling is less of an issue, this method could be implemented along with soil moisture measurements by neutron probes to make an accurate assessment of water requirements and reduce losses by over-irrigating.

3. **Optimisation of irrigation-scheduling at all farms**. This should be guided by the cultivar specialist (Mr Brits) and should include farm-specific operating rules

Figure 23: Overhead irrigation of hops (right) results in higher losses of water which does not reach the rooting zone, but has the additional advantage of cooling the crops during hot periods. Drip irrigation (left) and below ground irrigation have lower water losses.

on when to irrigate, by how much, and for how long. This should be informed by on-farm measurements of air temperature, wind speed, soil moisture and observations of crop turgidity. A farm-scale water audit by registered South African Irrigation Institute (SAII) irrigation designers would support the irrigation optimisation, and would assess the supporting water infrastructure. This supports the optimisation of water application efficiency of irrigation systems, including pressure regulation, pipe specifications.

4. **Improved management of the drainage system** to minimise erosion during extreme rainfall events (Figure 24). Drainage gullies next to the hops fields need to be stabilised to minimise the risk of erosion during extreme events. Loss of topsoil degrades the condition of the land and reduces the storage capacity of on-site dams, while increasing nutrient input to dams.

5. **A hydrocensus of existing boreholes and drilling logs** is required at a farm scale to support the previous response strategy for improved water resource monitoring. This should be done in conjunction with a qualified hydrogeologist (a member of the Groundwater Division of the Geological Society of South Africa). The hydrocensus will identify: 1 - which geological targets and fault zones in the area are water-bearing; and 2 – the location of all farm boreholes, including disused boreholes which can form part of the monitoring infrastructure.

6. **Artificial recharge of groundwater at a farm-scale** may be considered as a more effective (sub-surface) storage of water, particularly with climate change. Higher temperatures will exacerbate losses of surface water to evaporation and increase the risk of eutrophication (algal blooms) in dams. Water is naturally stored underground, but the recharge process can be enhanced via boreholes or infiltration ponds and ditches in areas where there is available (permeable) aquifer storage space that is not naturally filled during the rainy season. The hops farms may have some areas of deeper alluvium which could store additional groundwater in the valley bottom. The potential for this on individual farms would need to be assessed by a qualified hydrogeologist.

Scale and costs:

The scale and costs of farm-scale implementation is site specific and will rely on different sub-contractors and suppliers. Each farm will need to cost appropriate interventions at their sites.

Benefits:

Water:

Improved water use will result in lower water usage. Drip irrigation typically operates at 90% application efficiency while a permanent over-head impact sprinkler (optimally scheduled to avoid high wind periods) operates at 75% efficiency. The implementation of several measures could result in water savings of around 35% of current usage.

Economic:

Water savings will result in saved energy costs for pumping. Improvements in the general hydrological condition of farms should improve the quality of water available on the farm and down-stream. This reduces the risk of increased water treatment costs.

Figure 24: Loss of topsoil during extreme events (left) degrades the agricultural area and reduces the storage capacity of on-farm dams. Optimal design of drainage gullies with stabilising boulders (right) can decrease this risk.

Ecological integrity:
Improved water use efficiency should reduce the water required in the hectares of hops cultivated remains the same. Lower water requirements and water impacts from sediment erosion and return flows with higher nutrient levels, improve the quality and quantity of water in the catchment.

Management benefits:
The responses outlined at a farm-scale generally require more involvement from the farmer (and labourers) in managing water resources and irrigation infrastructure. This will be a cost to the farmer, however, with a benefit of increasing water security.

Conclusions from Response Strategies:
Implementing these recommended actions will greatly enhance the resilience of SAB Hop Farms Pty operations in the area. Through the implementation of these three response strategies, SAB should be able to mitigate the majority of future water risks to their hop farm operations. The rehabilitation of the hydrological and ecological functionality of the Waboomskraal and Herold nested catchments will yield water and economic benefits that far outweigh future threats from climate change. Similarly, future threats from competition for water in this region are likely to be greatly reduced through SAB Hop Farms Pty Ltd taking a leadership role in development of a groundwater monitoring framework and institutional structures that are able to engage effectively with decision-making processes from an informed and science-based position.

These actions will also yield number of other direct risk-reduction benefits (e.g. fire risk reduction, erosion control and enhancement of labour-relations) to SAB Hop Farms Pty Ltd as well as indirect benefits through building SAB's brand equity as a proudly South African brand taking a leadership position on a critical resource that underpins its product. The response strategies will not only benefit SAB, but will also deliver broader societal benefits through the replenishment of water to these catchments, the restoration of ecological services, and security of critical biodiversity assets. This is likely to enhance SAB's relationships in the region with key stakeholders (e.g. municipalities, Water Affairs and conservation agencies) as well as the broader community.

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