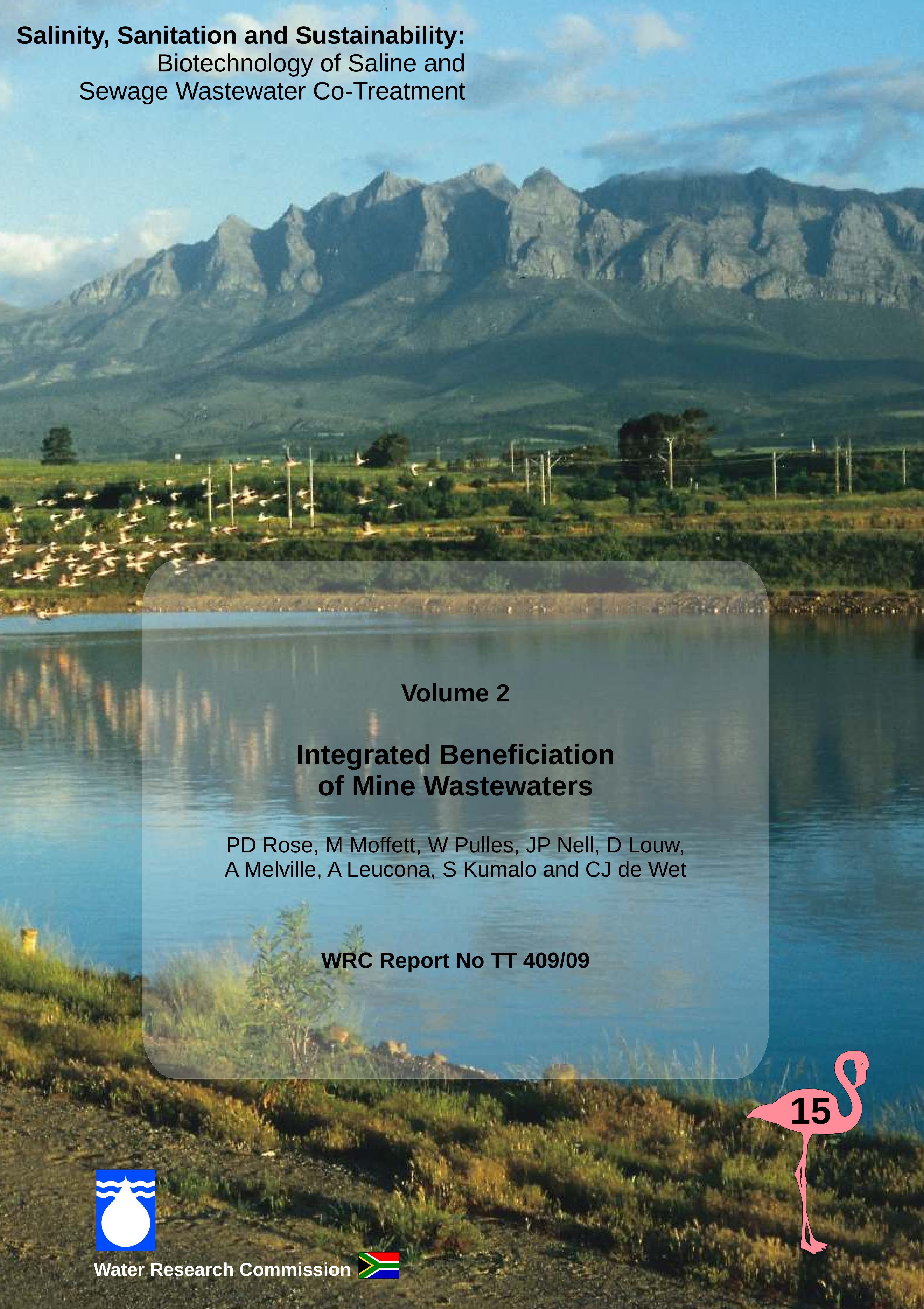

Salinity, Sanitation and Sustainability:
Biotechnology of Saline and
Sewage Wastewater Co-Treatment

Volume 2

Integrated Beneficiation of Mine Wastewaters

PD Rose, M Moffett, W Pulles, JP Nell, D Louw,
A Melville, A Leucona, S Kumalo and CJ de Wet

WRC Report No TT 409/09

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Water Research Commission

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Cover Photograph:

Flamingoes on tannery wastewater ponds at Mossop Western Leathers Co., Wellington, South Africa. The presence of Phoenicopteridae, including both the Greater and Lesser Flamingo, is an important indicator of healthy and naturally functioning saline aquatic ecosystems. This flock occupied the ponding system shortly after commissioning the novel *Spirulina*-based Integrated Algal Ponding System which had been developed for the treatment of tannery wastewaters. This apparent seal of environmental approval became an icon for the studies which followed in this series.

Photograph by Roger Rowswell, whose observation of this system, over a number of years, was instrumental in the initiation of these studies.

SALINITY, SANITATION AND SUSTAINABILITY:

BIOTECHNOLOGY OF SALINE AND SEWAGE WASTEWATER CO-TREATMENT

VOLUME 2

INTEGRATED BENEFICIATION OF MINE WASTEWATERS
Mine Drainage Wastewater Treatment and Planning
for the Social and Labour Component
in Sustainable Mine Operation and Closure

Case Study for a Spatial Development Initiative
in Eastern Ekurhuleni

PD Rose, M Moffett, W Pulles, JP Nell, D Louw, A Melville,
A Leucona, S Kumalo and CJ de Wet

Report to the
Water Research Commission

by

Environmental Biotechnology Research Unit, Rhodes University, Grahamstown
Department of Anthropology, Rhodes University, Grahamstown
Pulles Howard & de Lange Inc., Johannesburg
Institute for Soil Climate and Water, Pretoria
Optimal Agricultural Business Systems, Paarl
Public Domain Management, Johannesburg

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The publication of this report emanates from a project entitled: “Biotechnological co-treatment of saline and sewage wastewaters with integrated recovery and reuse of water and organic and inorganic components for sustainable development’ (WRC Project K5/1456).

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PREFACE

Sustainable development is, in an important sense, technologically dependent. Thus the ability to manage and treat a range of complex wastes plays a determining role in the health, and hence the long-range sustainability, of the environment in which the development takes place. Salinity is one such complex problem that has become an increasing threat to the water-scarce, inland industrial development of South Africa.

The Water Research Commission (WRC) has funded an innovative response to the problem which has focussed on the synergies available in the co-treatment of saline and domestic wastewaters. The development of novel biotechnological processes in a number of WRC projects (such as the Rhodes BioSURE® Process treating acid mine drainage) has targeted the recovery from the saline sewage co-treatment operation of not only treated water, but also value-added products which may impact the financial viability of the remediation exercise. The core process technology opens up possibilities for development scenarios in which social, economic and environmental interests ("Tripple Bottom Line" economics) could be managed in an integrated manner. This would enable incorporating domestic sanitation, industrial pollution control, water resource provision to a range of users and stimulation of community economic activities and thereby also ensuring environmental protection.

The project reported here has been undertaken to advance individual key aspects of the saline sewage co-treatment research programme initiated at Rhodes University and has been managed as a collaborative research effort including the Environmental Biotechnology Research Unit and Anthropology Department (Rhodes University), Department of Civil Engineering (University of Cape Town), the Pollution Research Group (University of KwaZulu-Natal), Pulles Howard & de Lange Inc., Public Domain Management and the ERWAT Water Care Company. The research project consisted of four separate parts and the results of the studies undertaken have been published in a two-volume series as outlined below.

PART 1. An exploratory study of potential in using saline wastewaters for the reticulation and treatment of domestic and industrial wastewaters. This report includes a review of current thinking and practice in dual reticulation systems and a preliminary evaluation of the use of Integrated Algal Ponding Systems for the treatment of such wastewaters was undertaken. The potential for a more detailed follow-up programme in this area has been considered. This investigation has been reported together with WRC Project K5/1621.

PART 2. Further development of the Rhodes BioSURE® Process for the co-treatment of mine wastewater utilising sewage sludge as an organic carbon source. A detailed investigation of process kinetics was undertaken and the mathematical modelling of the constituent processes has been reported in Volume 1 of this series. This part of the project has combined the outputs of a number of other WRC projects relating to the modelling of anaerobic system and in doing this has emerged as a major study in its own right titled "Integrated Physical, Chemical and Biological Process Kinetic Models for Anaerobic Digestion of Primary Sewage Sludge". This report constitutes an important contribution to an understanding of both sulphidogenic and methanogenic systems.

Downstream treatment of sulphidic wastewaters generated in the Rhodes BioSURE® Process was also investigated. The biofilter component of this study has been reported together with WRC Projects K5/1169 & 1291 and the sulphide oxidation study together with WRC Projects 1078, 1336 & 1545.
PART 3. Investigation of the potential for a novel development of hybrid mine wastewater treatment technology to bridge the gap between active and mine closure operations. This study has been reported but due to novelty implications will not be published until further process development has been undertaken.

PART 4. Investigation of the feasibility of the Integrated Community Benefit concept in which treated mine waters may be used in horticultural enterprise development and thus provide sustainability in the mine operational and closure environments. An industry review was undertaken including a report on the technical, business and economic, and the community components of the Minewater reuse Waste Beneficiation concept. A case study on the application of the system was investigated in the Eastern Gauteng region. This study has been reported in Volume 2 of the series.

The WRC Project 1456 has thus complemented and supported a number of investigations being undertaken concurrently in closely associated WRC Research Projects related to technology development in Sewage and Saline Wastewater co-treatment. In providing incremental steps in a number of key areas, the overall objective of Waste Beneficiation has been advanced in which technology provides an enabling platform for wastes to be managed as resources with economic potential rather than as a dead cost to both the community and the environment.

Peter Rose
Project Leader

EXECUTIVE SUMMARY

INTRODUCTION

Mine closure is regarded as one of the most difficult issues facing the mining industry worldwide today, and closing mines successfully has become more problematic than opening them. It is now generally accepted that effective mine closure planning should start at the mine conceptualization stage (Strongman, 2000).

In South Africa, the governance of mining activity, including both the operation and closure phases, is outlined in the new Mineral and Petroleum Resources Development Act (MPRDA, 2002), and is based on the principles of sustainable development. Far-reaching requirements have been put in place for the Environmental Management, Closure, and Social and Labour planning in both the establishment of the mining activity and in licensing its closure. Thus, in addition to meeting the long-term environmental objectives associated with mining activities, the Act also aims "to promote employment and advance the social and economic welfare of all South Africans, and to ensure that holders of mining rights contribute towards the socio-economic development of the areas in which they are operating" (MPRDA, 2002).

In the environmental domain, and following rehabilitation and reclamation works, the ongoing treatment of mine drainage wastewaters presents one of the longest residual commitments of the mining legacy following closure. It is also one of the most problematic to manage on a sustainable basis, and demonstrating effective provision for water treatment over the decades that follow the end of operations is one of the principal constraints in achieving final closure certification and walk-away by the mining company (Bosman and Kotze, 2005).

This study examines the opportunity potential for linking the requirements for water treatment and social planning and, in so doing, to demonstrate the necessary sustainability in both the operational and closure phases of the mining undertaking.

MINE WASTEWATER BENEFICIATION

The idea of resource beneficiation is not novel in the mining industry, and the recovery of value from mining wastes is widely and successfully practiced. The beneficiation of mine wastewaters and their use as a resource has, however, been less developed.

Integrated Wastewater Beneficiation has become a particular focus in sustainability thinking over the past 15 years and has built on the foundation of earlier work on water recycle and reuse strategies, which have increasingly come into prominence as scarce water resources have been exhausted (Levine and Asano, 2002). The beneficiation of mine wastewaters as a resource in both implementing the Social and Labour plan and enabling mine closure thus has a potentially firm base in established sustainability thinking.

However, Lens et al. (2002) have noted that while the closure of resource and material cycles underpinning integrated resource management objectives, and the so-called dematerialisation of the economy, have become popular policy concepts within sustainability programmes, the scientific basis for these ideas remains weak, and the technological means for achieving these goals are still largely undeveloped. Considerable work is thus required to convert these concepts into fully operational systems.

AN AGRICULTURAL SPATIAL DEVELOPMENT INITIATIVE IN EASTERN EKURHULENI

The Blesbokspruit wetland system in Eastern Ekurhuleni (Springs/Nigel) is one of the few permanent wetlands in the Gauteng region (SSI, 1997), and its designation as a Ramsar site in 1986 imposes stringent international obligations in its management. Both the catchment and the wetland are threatened by deteriorating water quality (increasing salinity in particular), and rising volumes of water discharge due to mine dewatering operations and the accelerating population growth in the region.

With the closure of gold mining activity in the area over the past 15 years, the dewatering of the East Rand Basin has fallen to Grootvlei Mine, the last operational mine in the area, and the pumping of 70-130 Mℓ/day mine drainage wastewater has been required to maintain operations. The installation of a High Density Sludge plant has reduced iron oxide contamination, but Nell and Lea (2003) have noted that calcium and sulphate are now the predominant cations and anions in the wetland. In a study of long term prospects, Scott (1995) has shown that decanting of the East Rand Basin will commence within a few years of the final closure of Grootvlei Mine and then will continue to discharge polluted waters for many decades or possibly centuries.

The closure of some 24 mines, after nearly a century of intensive activity, has also had a profound impact on the economy of the Eastern Ekurhuleni region and, in addition to large-scale unemployment and depressed economic activity, numerous informal settlement communities (squatter camps) have sprung up in the area. Reduced employment has resulted in the dislocation of communities and accompanying social problems. Solutions are thus urgently required to deal not only with mine water treatment in the immediate operational and post-closure phases, but also to consider the social legacy of long-term gold mining activity as a regional problem.

The concept of an agricultural Spatial Development Initiative (SDI) has been advanced as a basis for linking the treatment of mine water, and the resolution of social needs, and in so doing to ensure a sustainable legacy to mining operations in Eastern Ekurhuleni. Where appropriate technology is available, and a good quality water can be guaranteed, it is possible to conceptualise irrigation-based agricultural activity as a structured response in the provision for ongoing socio-economic security. Where the cost of treatment is low in the post-closure phase, the incentive to maintain the water treatment function will lie with the agricultural operator and thus, following the setting up of the necessary infrastructure, the responsibility for sustainable management of the site may ultimately pass from the mining company to the agricultural enterprise.

This project has thus undertaken an examination of the feasibility of the establishment of the SDI as a case study of the integrated beneficiation of mine wastewaters, and in which meeting the environmental and the social and labour requirements for sustainable mine operation and closure may be accomplished.

OBJECTIVES

The WRC commissioned the current analysis of the agricultural implications of the Grootvlei/Erwat mine wastewater treatment operation as a case study in which to investigate the feasibility of the irrigated agriculture/mine water treatment proposal as an economically viable basis for long-term sustainability in the environmental and social aspects of mine operation and closure.

METHODOLOGY

The following steps were identified:

- To undertake a case study investigating the feasibility, potential scale and location of an Integrated Mine Wastewater Beneficiation scheme. This would include an investigation of the physical environment, identifying the range of potential economic activities that could be coupled to the biological treatment of mine water and to evaluate these in terms of technical requirements (water quality, nutrients, sensitivity, degree of care required, etc.) skills requirements (basic and advanced technical and managerial skills), economic requirements (capital and operating costs), market requirements (proximity of markets, shelf life, competition, current supply & demand, etc.) and business models to ensure project sustainability. A potential application in Eastern Ekurhuleni was identified as the investigation site;

- In terms of social planning to investigate the social dynamics governing the interaction between parties involved in the implementation of social benefit schemes within the context of an application in the Eastern Ekurhuleni Region;

- Make proposals for follow-on actions required to implement the concept.

Execution of the study and planning for the SDI has been undertaken by a research team led by the Rhodes University Environmental Biotechnology Research Unit (EBRU) and involved the following activities:

- Development and implementation of appropriate bio-desalination water treatment technology and determining the quality of the treated water to be used as the basis of the study – Rhodes University EBRU and Erwat;
- Situation assessment and physical planning for the proposed SDI – Pulles Howard & de Lange Inc.;
- Assessment of water quality and climatological aspects on crop production in the Blesbokspruit area – Institute for Soil Climate and Water, Agricultural Research Council;
- Assessment of agricultural crop production potential – Optimal Agricultural Business Systems;

- Development of a strategic business model for intensive v vegetable production in Eastern Ekurhuleni – Public Domain Management and African Management Solutions;
- Investigation of the social dynamics of the informal settlement/unemployed communities living in the area and who might become involved in the proposed SDI – Rhodes University Anthropology Department and Women Resources Management;
- Proposals relating to future activities including planning and managing the process of stakeholder involvement in the development of the scheme and its implementation – WRC Research Team.

MINEWATER TREATMENT TECHNOLOGY

Recent technology developments have focussed on the use of complex organic substrates for the low-cost biological treatment of mine drainage wastewaters (Rose et al., 2002). In the Rhodes BioSURE Process®, developed by the Environmental Biotechnology Research Unit (EBRU), (research sponsored by the Water Research Commission and BioPAD) sewage sludge is used as the carbon source (Rose et al., 2002; Whittington-Jones et al., 2002). In linking the treatment of the minewastewater as an associated utility operation, conditions are established for long-term sustainability of treatment and also in which agricultural application of the water might be sustainable over the long-term.

The scale-up development and application of the Rhodes BioSURE Process has been undertaken in Springs by the East Rand Water Care Company (Erwat) at its Ancor Works, and treating the wastewaters from the Grootvlei Mine some 2.5 km away (Rose et al., 2002). The first full-scale application of the process was launched in January 2005 as a joint Erwat/Grootvlei Mine project. Treatment of 10ML/day is planned to be operational by September 2005, and when fully implemented between 30-70 ML/day treated minewater will be discharged to the Blesbokspruit. This site is immediately adjacent to a corridor of used mining and other lands stretching from Springs to Nigel along the banks of the Blesbokspruit wetland.

PHYSICAL ASSESMENT

Physical planning and site assessment was undertaken by Pulles, Howard and de Lange Inc. and involved mapping of the site, establishing current land use patterns and existing spatial development planning by Ekurhuleni Metropolitan Municipality (EMM). The population distribution and socio-economic characteristics of the area was considered and water resource usage reported.

This study indicated that an area of about 2600 ha was available in the Springs/Nigel corridor. While this would need ground-truthing in a detailed follow-up study, both suitable agricultural soils and spoiled mine ground and reclaimed dump areas were identified. The latter could be used for hydroponics production where direct soil contact should be avoided.

WATER QUALITY AND CLIMATE

An assessment of water, soil and climatic requirements for crop production in the area was undertaken by the Agricultural Research Council Institute for Soil, Climate and Water. A list of potential crops was identified which would be suitable for production in the Eastern Ekurhuleni region, and this was used in the subsequent investigations of both extensive and intensive agricultural production models evaluated.

The suitability of treated water quality for irrigation was considered for both reverse osmosis (RO) and the BioSURE® treatment options. It was reported that the sodium absorption ratio (SAR) of the Grootvlei/Ancor BioSURE® treated water would only be raised about 17% in the blending operation and that this would be suitable for crop production. This compared to an elevated SAR of some 142% for the RO option, and 244% for the partly treated water, which would raise severe problems for crop production using treated water in this area.

FINANCIAL FEASIBILITY

Two models for the irrigated agricultural production enterprise were considered.

The assessment of crop production in an extensive open land operation was undertaken by Optimal Agricultural Business Systems. The economics of a wide range of potential crops was considered and a detailed costing study undertaken on the basis of a large, professionally managed agri-business enterprise absorbing all the treated water. For the 10 ML/day water production scenario it was found that a net farming income of R9.3 million could be generated on a land area of 515 ha and that 567 permanent jobs could be created in this way.

Intensive horticultural production using hydroponics systems was also investigated and reported by Public Domain Management. Intensive vegetable production was considered and local marketing conditions were examined in formulating a production programme on which a detailed costing study was based.

While more detailed studies will be required for detailed implementation planning of the proposed SDI, the studies reported here do enable the formulation of a hypothetical picture of potential water, land, and job creation potential for the scheme, and a potential net farming income may be computed based thereon. This has been summarised in Table 10.1 and indicates that some 113 farming and gardening enterprises may be established in this way and generating around 950 additional permanent jobs and a net farming income for the scheme of R26 million.

Clearly the system could act as an incubator for the development of agricultural entrepreneurial skills which could, in time, relocate to other possibly more productive enterprises.

Table 1: Summary of water, land use and job creation potential in a hypothetical allocation of resources in the proposed Springs/Nigel SDI in Eastern Ekurhuleni including agri-business, farming entrepreneur development and urban gardening.

	Area (ha)	Water Usage (ML/day)	Owner/operators	Jobs	Net Farm Income (R)
Agri-business	300	8	3	400	14
Farming EDP	300	8	35	300	7
Urban garden	250	14	75	250	5
Totals	850	30	113	950	26

SOCIAL DYNAMICS

Daggafontein informal settlement community has been located within the proposed SDI area for many years, and would be a major participant in the proposed scheme in terms of labour provision and possibly entrepreneur development. In order to understand the social dynamics underpinning such communities, and the indicators for their successful involvement in the scheme, a study was undertaken by the Rhodes University Anthropology Department.

Based on the socio-economic profile that emerged from the Daggafontein study, the following conclusions were drawn relating to the viability of the proposal:

- Nearly 75% of respondents in the study had some experience with cultivation and came from a rural agricultural background. This provides a good indicator of success for employment opportunities in the scheme and involvement in the urban garden proposal initially;

- Education levels are moderate with almost half the respondents having some high school education, but only 16% completed 12 years of schooling. This profile would well fill the requirement of manual labour which requires literacy and numerical competence;

- A fair amount of entrepreneurial activity was found in Daggafontein, especially among young people, and this could provide the recruitment base from which future managers are drawn;

- Residents were found to be committed to the area and would be participants in the ongoing development of the community;

- Local government structures at the Ward level were not found to be functioning optimally and require attention in maintaining communication with the community involved. The project will thus need to liaise and work closely with local government if it is to be accepted and to succeed, and this will need to be pro-actively and systematically developed, and a sound working relationship cultivated on an ongoing basis.

INDICATORS FOR SUCCESS AND FAILURE

A number of indicators for the potential success of the project emerged during the course of the study and have been summarised as follows:

- Available expertise to treat the polluted mine and sewage water;
- Sufficient treated water for hydroponic cultivation;
- Available land in the area for developing hydroponic cultivation;
- Potentially large amounts of semi-skilled labour in informal settlements and townships near Grootvlei Mine;
- Training resource and experimental facilities via ANCOR Sewage Works;
- Predominantly small-scale entrepreneurs in communities such as Daggafontein;
- Potential markets for vegetables in the surrounding townships, in the Ekurhuleni Metropolitan Municipality and in the Gauteng region;
- Supportive Response from officials at Ekurhuleni Metropolitan Municipality;

Indicators for potential failure or problems include:

- The capital-, management- and labour-intensive nature of hydroponic cultivation;
- Senior level administrative and financial management will have to be recruited from outside, therefore there will be a continuous 'top down' component to the project, with community members always being in only the more junior administrative positions;
- Need for "24/7" availability of labour;
- Strong rural component in the responses and behaviour patterns of many of the respondents interviewed;
- Limited effectiveness of current local leadership and local government structures at the Ward level;
- Inevitable political tussles when significant new resources are made available which could be severely disruptive in the context of local government structures that are still struggling to find their feet and operate effectively.

RECOMMENDATIONS

The study of the proposed Springs/Nigel SDI reported above has indicated an overall guarded optimism for successful outcomes based on the preliminary physical, technical, economic and social investigations reported here. Clearly this remains a first order assessment of feasibility and would require a much more detailed follow-up to provide the rigorous and detailed planning structure on which to proceed.

The following recommendations are thus made as a guide to follow-up steps that need to be addressed:

- The Springs/Nigel SDI would be a regional development programme and thus participative structures would need to be set up in which the local communities, local government, the EMM, the mines and ERWAT, DWAF, and Provincial and National Government may become involved;

- The preliminary report, as detailed here, provides a basis for initial discussions and the planning of future activities;

- Without prescribing how this programme may develop, a follow-up in-depth investigation will need to expand on the preliminary nature of the current report and generate a detailed bankable business plan underpinning the proposed development. This will need to include confirmation of physical and environmental resource estimates, mapping of the proposed agricultural use areas, revisiting market estimates, confirming sources of funding and constructing the business plan;

- The business plan will need initial green-lighting from EMM, and may be best managed by a programme co-ordinator who will need to facilitate a complex process of negotiations and iterations in bringing the idea to fruition;

- It is recommended that an NGO funding agency be approached to fund the business planning and the detailed scheme development phase, and that some level of autonomy exist here so that technical concept development does not get bogged down in the necessary, but possibly time-consuming, process of political interaction;

- Ultimately EMM will need to assume ownership of the scheme, but may decide to postpone that decision until the detailed study has been completed;

- The study reported here provides a model for comparable situations of mine closure both in South Africa and around the world. Thus given the wider ambit, donor funding should be sought from interested parties internationally to fund at least part of the proposed development as a case study for similar interventions required elsewhere.

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LIST OF ABBREVIATIONS

AMD	Acid Mine Drainage
ARC	Agricultural Research Council
DACEL	Department of Agriculture, Conservation, Environment and Land Affairs
DEAT	Department of Environmental Affairs and Tourism
DWAF	Department of Water Affairs and Forestry
EBRU	Environmental Biotechnology Research Unit
EC_e	Electrical Conductivity Soil Extract
EC_w	Electrical Conductivity, Water
EDP	Entrepreneur Development Programme
EMM	Ekurhuleni Metropolitan Municipality
EMP	Environmental Management Plan
ERWAT	East Rand Water Care Company
EU	European Union
FAO	Food and Agriculture Organisation
FVC	Fruit and Veg City
GSA	Grain South Africa
Ha	Hectare
ISCW	Institute for Soil, Climate and Water
JFPM	Johannesburg Fresh Produce Market
LF	Leaching Fraction
m^3	Cubic Meter
ML	Mega litre
MPRDA	Minerals and Petroleum Resources Development Act
mS/m	Milli Siemens
NEMA	National Environmental Management Act
NFI	Net Farming Income
NGO	Non-Governmental Organisation
NPV	Net Present Value
PHD	Pulles Howard and De Lange
RO	Reverse Osmosis
SADC	Southern African Development Community
SAGIS	South African Grain Information Services
SAR	Sodium Absorption Ratio
SDI	Spatial Development Initiative
SHAFE	Southern Hemisphere Fresh Produce Exporters Forum
SMME	Small Medium and Micro Enterprise
Tx	Mean daily maximum temperature (°C)
Tm	Mean daily average temperature (°C)
Tn	Mean daily minimum temperature (°C)
Txh	Mean of monthly maxima of maximum temperatures (°C)
Tnl	Mean of monthly minima of minimum temperatures (°C)
TDIS	Total Dissolved Inorganic Solids
UN	United Nations
USDA	United States Department of Agriculture
WCW	Water Care Works
WRC	Water Research Commission

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The authors would like to acknowledge the generous support and encouragement of Erwat Water Care Company, Grootvlei Mine (Pty) Ltd. and the Ekurhuleni Metropolitan Municipality in the development of the study reported here. Thanks to Martin Schermers and Irene Lea for making available the water quality and agronomic studies by Daan Louw and Piet Nell undertaken concurrently with the other components of the study and commissioned by Grootvlei Mine. Their work has added greatly to the scope of this report. Lebo Kamohi of Menyetla made valuable contributions to the social dynamics study at Daggafontein informal settlement.

1. INTEGRATED VENEFICIATION OF MINE WASTEWATERS

1.1 BACKGROUND

1.1 SUSTAINABLE MINE OPERATION AND CLOSURE

Mine closure is now regarded as one of the most difficult issues facing the mining industry worldwide today, and closing mines successfully has become more problematic than opening them (Strongman, 2000). It is now accepted that effective mine closure planning should start at the mine conceptualization stage, and this can have profound effects on the design of the mine, the water management policy and especially the social infrastructure developed during its operation.

In South Africa, the governance of mining activity, including both the operation and closure phases, is outlined in the new Mineral and Petroleum Resources Development Act (MPRDA, 2002), which became operational in 2004. This is squarely based on the principles of sustainable development as framed in the National Environmental Management Act (NEMA), and far-reaching requirements have been put in place relating to the Environmental Management Plan (EMP), Closure Plan and Social and Labour Plan in both the establishment of the mining activity and in licensing its closure. Thus, in addition to meeting the long-term environmental objectives associated with mining activities, the Act also aims "to promote employment and advance the social and economic welfare of all South Africans, and to ensure that holders of mining rights contribute towards the socio-economic development of the areas in which they are operating" (MPRDA, 2002).

While the Social and Labour Plan covers the management of socio-economic aspects of the mine's ongoing operations, in the closure phase it must also address mechanisms to save jobs, avoid job losses and a decline in employment, provide alternative solutions for creating job security, and ameliorate the social and economic impact on individuals, regions and economies where retrenchment or closure of the mine is imminent (regulations 41-46, MPRDA, 2002).

In the environmental domain, and following rehabilitation and reclamation works, the ongoing treatment of mine drainage wastewaters presents one of the longest residual commitments of the mining legacy following closure. It is also one of the most problematic to manage on a sustainable basis, and demonstrating effective provision for water treatment over the decades that follow the end of operations is one of the principal constraints in achieving final closure certification and walk-away by the mining company (Bosman and Kotze, 2005). Thus water treatment and social and labour planning are two of the long-term aspects to be addressed.

This study examines the opportunity potential for linking these requirements and, in so doing, to demonstrate the necessary sustainability in both the operational and closure phases of the mining undertaking. As Strongman (2000) has noted, this is best implemented while the mine is in full operation.

Where appropriate technology is available, and a good quality water can be guaranteed, it is possible to plan irrigation-based agricultural activity as a structured response in the provision for ongoing socio-economic security. Where the cost of treatment is low in the post-closure phase, the incentive to maintain the water treatment function will lie with the agricultural operator and thus, following the setting up of the necessary infrastructure, the responsibility for sustainable management of the site will ultimately pass from the mining company to the agricultural enterprise.

Recent technology developments have focussed on the use of complex organic substrates for the biological treatment of mine drainage wastewaters (Pulles, 2002; Rose et al., 2002), and studies in the development of a Hybrid Systems Technology approach have commenced where the water treatment plant constructed to handle operational dewatering treatment requirements may be retained to treat post-closure decant streams (WRC study in progress).

Scott (1995) has shown that decants from the East Rand Basin gold mining area will continue for many decades following the closure of Grootvlei Mine, the last remaining mine actively pumping to maintain working operations in this system (75-130 Mℓ/day). Solutions are thus required here for both an immediate operation and a long-term post closure phase.

The WRC has commissioned the current analysis of the agricultural implications of the Grootvlei/Erwat mine wastewater treatment operation as a case study in which to investigate the feasibility of the irrigated agriculture/mine water treatment proposal as an economically viable basis for long-term sustainability in the environmental and social aspects of mine operation and closure.

1.2 SALINITY AND MINE DRAINAGE

Salinisation of the public water system has been identified as one of the single most serious pollution hazards threatening the environment in South Africa (Commission Report, 1970; Best, 1984; DWA, 1986; Stander, 1987; Du Plessis, 1990; DEAT, 2000). Although a great deal of effort has been expended in dealing with this problem over the past 30 years, the current position remains one of continuously increasing salinities, and it has been noted that water quality management strategies and pollution control measures put in place to deal with the problem tend on the whole to conceal this underlying trend (Foster, 1990; Rose, 2002). Both natural and anthropogenic sources are involved.

The mining industry, among others, is a major contributor to surface water salinity, and introduces both sodium chloride and sulphate salts in the dewatering of subsurface workings as well as the decanting of closed mines. Total salts discharges from coal mines of 130 000 tons.year^{-1} and from gold mines of 200 000 tons.year^{-1} were estimated in the early 1990s (Annandale et al., 2002), while Heyneke (1987) had estimated that 400 000 tons.year^{-1} reached the Vaal River system alone.

Pyrite deposits occur in most South African gold and coal mines and on exposure to oxygen and the catalytic action of sulphide oxidising bacteria, the iron pyrite is oxidised to sulphuric acid. In addition to iron, a number of heavy metals may be brought into solution producing the ‘Yellow Boy’ deposits which have been known at least since Roman times (Wildeman, 1991). These waters are typically strongly acidic with total dissolved organic solids (TDIS) levels up to 7g.L^{-1} (Maree & Du Plessis, 1994). Sodium chloride is introduced where mining activities are associated with marine geological deposits such as occur in the Karoo System.

Dewatering of mines may require pumping of up to 130 ML.day^{-1} and it has been estimated that when mine pumping operations finally cease, filling of the voids would occur within a decade, and to be followed by long-term AMD flows (Scott, 1995). In the case of 'vestigial acidity' the void flushing process may be completed in 40-50 years. However, where 'juvenile acidity' occurs, arising from on-going pyrite oxidation in the zone of water table fluctuation, AMD flows may be expected to continue for many hundreds of years, until the inventory of the pyrite deposit is finally exhausted (Younger *et al.*,1997).

The long-term nature of the problem, potentially extending over generations, and the large volumes of AMD requiring pumping and treatment, present particular challenges for the mines during both their productive life, and also in meeting the conditions laid down for licensed mine closure. Leaving aside retrenchment costs, the largest expense associated with mine closure arises from the legal environmental rehabilitation requirements (Reichardt, 2001). Where the treatment requirement will run from decades to centuries, the environmental liability can be expected, over time, to fall inevitably to the community at large. In addition to this liability, severe social problems accompany mine closure and, worldwide, the scaling down of mining operations is associated with reduced economic activity, rising unemployment, poverty and crime. While the extensive infrastructure that develops together with mines such as housing, commercial premises, and educational and recreational facilities may remain intact, the removal of the primary well-spring of economic activity results in a generally un-reversable social and economic decline. The full impact of this becomes apparent when it is realised that each mine worker in South Africa, on average, supports 9-11 dependents (Reichardt, 2001).

In terms of current concepts in sustainability (UN, 1992), the above scenario of mine closure associated with increased pollution load and declining economic activity, undermines the target objectives set out in Agenda 21 for achieving "triple bottom line" sustainability accounting in terms of environmental, economic and social criteria.

2. MINEWATER BENEFICIATION

The idea of linking the mine wastewater treatment function and the use of the treated water in the development of an agriculturally-based economic hub around mines, during their productive lives, has been considered as a possible solution to the apparently otherwise insoluble mine closure problem-scenario outlined above (Rose, 2002). Integrated Wastewater Beneficiation has become a particular focus in sustainability thinking over the past 15 years and has built on the foundation of earlier work on water recycle and reuse strategies, which have increasingly come into prominence as scarce water resources have been exhausted (Levine and Asano, 2002).

The idea of water beneficiation is not novel in the mining industry; the beneficiation concept itself is in well established use, and recovery of value from mining wastes is widely and successfully practiced. The MPRDA (2002) identifies the beneficiation of mining raw materials and commodities as a principal target in enabling broader participation in the industry of previously disadvantaged groups. The use of treated mine wastewaters in Community Benefit programmes has been considered worldwide and a range of commercially viable activities have been investigated including aquaculture, fish production, irrigated agriculture, pastures and livestock, high value horticultural production and hydroponics.

Minewater treatment is normally a high-cost activity, and particular constraints arise in the technological capacity to undertake cost-sustainable water treatment after closure, and over the period during which the Community Benefit initiatives are supposed to be operational. Lens et al. (2002) have noted that while the closure of resource and material cycles, and the so-called dematerialisation of the economy, have become popular policy concepts within sustainability programmes, the scientific basis for these ideas remains weak, and the technological means for achieving these goals are still largely undeveloped.

3. PROJECT RATIONALE

In the current WRC study the development of novel technology is considered which would enable the linking of mine closure, mine wastewater treatment and Community Benefit initiatives as component operations in a sustainable approach to the problem described above. Development of Hybrid Systems Technologies which would enable both active and passive treatment systems to bridge the mine operational and closure/post closure periods has been considered and reported in an earlier section of the current “Biotechnology of Saline and Sewage Wastewater Co-Treatment” programme report.

One of these approaches is the Rhodes BioSURE Process®, a WRC/BioPAD sponsored development, that uses sewage sludge as the carbon source in a bacterially-driven process for sulphate salinity removal. Both heavy metals and acidity are also removed in this operation (Rose et al., 2002; Whittington-Jones et al., 2002). It has been proposed that in linking the long-term treatment of the mine wastewater as an associated utility operation, conditions are established in which sustainable agricultural application of the water might be considered at a level of economic activity sufficient to contribute to the mine closure requirement. However, it needs to be noted that the feasibility of such a proposal has not been tested on any large scale in South Africa, or possibly elsewhere.

The scale-up development and application of the Rhodes BioSURE Process® has been undertaken in Springs by the East Rand Water Care Company (Erwat) at its Ancor Works, and treating the wastewaters from the Grootvlei Mine some 2.5 km away (Rose et al., 2002). The first full-scale application of the process was launched in January 2005. Treatment of 10ML/day is planned to be operational by September 2005, and when fully implemented between 30-70 ML/day treated minewater will be discharged to the Blesbokspruit. This site is immediately adjacent to a corridor of used mining and other lands stretching from Springs to Nigel along the banks of the Blesbokspruit wetland.

3.1 THE BLESBOSPRUIT WETLAND

This wetland system is one of the few permanent wetlands in the Gauteng region (SSI, 1997), and its designation as a Ramsar site in 1986 imposes stringent international obligations in its management. The role of wetlands in enhancing water quality is well-known, and both water purification functions and recreational use underscores the significant economic importance of this system. The continued viable functioning of the wetland is thus important to all users of the Blesbokspruit catchment.

Both the catchment and the wetland are threatened by deteriorating water quality (increasing salinity in particular), and rising volumes of water discharge due to the accelerating economic and social development of the region. Nell and Lea (2003) have noted that calcium and sulphate are now the predominant cations and anions in the wetland. Increasing volumes in the wetland have also caused riparian flooding.

3.2 AN EASTERN EKURHULENI AGRICULTURAL SPATIAL DEVELOPMENT INITIATIVE

The mine land corridor between Springs and Nigel along the Blesbokspruit in Eastern Ekurhuleni has been proposed as a possible site in which a mine wastewater beneficiation programme might be considered, and in which the feasibility of this type of proposal could be studied. An agriculture-based Spatial Development Initiative (SDI) has been proposed as a possible structure for the programme and this fits well with Ekurhuleni Metro planning for an agricultural development node in this area.

Closure of the extensive mining industry in the Springs area over the past 15 years has left a legacy of economic decline, joblessness, growing poverty and informal settlement camps. In addition to the large volumes of treated water to become available from the Grootvlei/Ancor treatment project, large areas of low-value undermined ground and good quality soils are available on which job-creating agricultural development and urban gardening initiatives may be established.

Erwat has made land available for the development of an Experimental Horticultural Field Station at Ancor Works. This would provide experimental development of crop production systems utilizing treated wastewaters, specialist agricultural extension service support to horticulture business development in the SDI, and training support to emergent farmers and urban and peri-urban garden operators.

4. PROJECT OBJECTIVE

To undertake a case study of the Integrated Mine Wastewater Beneficiation concept, to test the practical requirements and feasibility of the proposal and to make recommendations for the implementation of such schemes.

5. METHODOLOGY

The following steps were identified:

- To undertake a case study investigating the feasibility, potential scale and location of an Integrated Mine Wastewater Beneficiation scheme. This would include an investigation of the physical environment, identifying the range of potential economic activities that could be coupled to the biological treatment of mine water and to evaluate these in terms of technical requirements (water quality, nutrients, sensitivity, degree of care required, etc.) skills requirements (basic and advanced technical and managerial skills), economic requirements (capital and operating costs), market requirements (proximity of markets, shelf life, competition, current supply & demand, etc.) and business models to ensure project sustainability. A potential application in Eastern Ekurhuleni was identified as the investigation site;

- In terms of social planning to investigate the social dynamics governing the interaction between parties involved in the implementation of social benefit schemes within the context of an application in the Eastern Ekurhuleni Region;

- Make proposals for follow-on actions required to implement the concept.

Execution of the study and planning for the SDI has been undertaken by a research team led by the Rhodes University Environmental Biotechnology Research Unit (EBRU) and involved the following activities:

- Development and implementation of appropriate bio-desalination water treatment technology and determining the quality of the treated water to be used as the basis of the study – Rhodes University EBRU and Erwat;
- Situation assessment and physical planning for the proposed SDI – Pulles Howard & de Lange Inc.;
- Assessment of water quality and climatological aspects on crop production in the Blesbokspruit area – Institute for Soil Climate and Water, Agricultural Research Council;
- Assessment of agricultural crop production potential – Optimal Agricultural Business Systems;
- Development of a strategic business model for intensive v vegetable production in Eastern Ekurhuleni – Public Domain Management and African Management Solutions;
- Investigation of the social dynamics of the informal settlement/unemployed communities living in the area and who might become involved in the proposed SDI – Rhodes University Anthropology Department and Women Resources Management;
- Proposals relating to future activities including planning and managing the process of stakeholder involvement in the development of the scheme and its implementation – WRC Research Team.

6 SITUATION ASSESSMENT AND PHYSICAL PLANNING

Melissa Moffett and W Pulles
Pulles Howard and de Lange, Inc.
Johannesburg

6.1 INTRODUCTION AND BACKGROUND

Gauteng is the industrial and financial hub of southern Africa and sustained in-migration of people into the region is expected. With an increase in the population, the issue of access to water becomes an important factor. Pulles Howard and de Lange (PHD) is part of a research group led by Rhodes University that is currently undertaking the research project on Biotechnological co-treatment of sewage and saline wasterwaters for the WRC. The development of this biotechnological water treatment technology will be able to improve the quality of substantial amounts of previously polluted mine water as well as sewerage water. This technology opens up possibilities for development scenarios in which social, economic and environmental interests can be managed in an integrated manner incorporating domestic sanitation, industrial pollution control, water resource provision to a range of users, stimulation of community economic activities and environmental protection.

The upper reaches of the Blesbokspruit catchment in Gauteng Province falls within the Ekurhuleni Metropolitan Municipality (EMM) and has been highly altered by catchment developments that include both formal and informal urbanisation, industrial growth and widespread mining activities. Discussions are currently being held between various parties with a view to applying the biotechnological water treatment technology using water from Grootvlei Mine and from Ancor sewage works. This treated water may be harnessed for promoting agricultural development initiatives that would involve nearby communities, as well as for returning it to the Blesbokspruit in an improved state.

Areas with agricultural potential in the EMM may be regarded as an opportunity to link the less privileged communities with the larger metropolitan area. These areas also create an opportunity for pilot urban agricultural projects. The specific community that is being considered in this pilot-scale project is the Daggafontein informal settlement. This informal settlement has approximately 800 housing units and is located close to Ancor sewerage works and to Grootvlei Mine (Figure 6.1).

6.2 OBJECTIVES

The broad objective of this project is to apply the biotechnological co-treatment of saline and sewage water in the Blesbokspruit Catchment area using water from Grootvlei Mine and from Ancor sewage works to:

- Improve the water quality of the Blesbokspruit, and
- Develop community components for employment opportunities, job creation, and other community upliftment benefits in the eastern EMM area.

Although this research is being undertaken on a pilot scale, one of the eventual aims is to use the treated sewage and mine water for agricultural activities on a large scale and thereby generate sustainable employment opportunities for nearby residential township communities. The size of the surface area that can be utilised for agricultural purposes will be determined by the volumes of water discharged by Grootvlei Mine and Ancor sewage works, and that can be treated through the application of the biotechnology process.

6.3 METHODOLOGY

Pulles Howard and de Lange (PHD) is responsible for the physical planning component of this study. The proposed methodology for this component includes the identification and a detailed description of the following aspects:

- Physical location and mapping of the area (Section 6.4.1). The eastern part of the EMM was considered during this study. Topographical maps and a GIS were used to compile maps of the area and to define the physical location of the site.
- Current land use, ownership and population distribution (Section 6.4.2). Information collated from various sources including the spatial development framework compiled by the EMM (Anon, 2002), miscellaneous reports and Statistics South Africa was used to determine this aspect.
- The socio-economic characteristics of the area were determined from available literature and are described in Section 6.4.3.
- Spatial Development Initiatives in the area (Section 6.4.4) were described based on information obtained from the EMM.
- Water resources of the Blesbokspruit are described in Section 6.5 and include background information on the Blesbokspruit (Section 6.5.1); information on the current discharge standards (Section 6.5.2); broad description of water users (Section 6.5.3) and water licences (Section 6.5.4).
- An estimate of the projected water quality requirements using the proposed biotechnology application is described in Section 6.6.
- A spatial development plan including recommendations that are based on the information collated during this study is described in Section 6.7.

It should be noted that the physical planning information contained in this report is not detailed or specific, but rather that it is a broad "snapshot" scenario of the current situation in the EMM. Detailed and more specific data verification through site visits may form part of later studies in this research project.

6.4. LOCALITY

6.4.1 Physical Location and Mapping

The infrastructure and components relevant to this biotechnology application study are located near the town of Springs in the East Rand and fall under the jurisdiction of the EMM. Specifically, the infrastructure and settlements referred to in this study include Grootvlei Mine, Ancor sewage works, Daggafontein Mine land and the Daggafontein informal settlement that is located on mine property belonging to ERGO (Figure 6.1). Figure 6.1 indicates the locality of the main components within the study area.

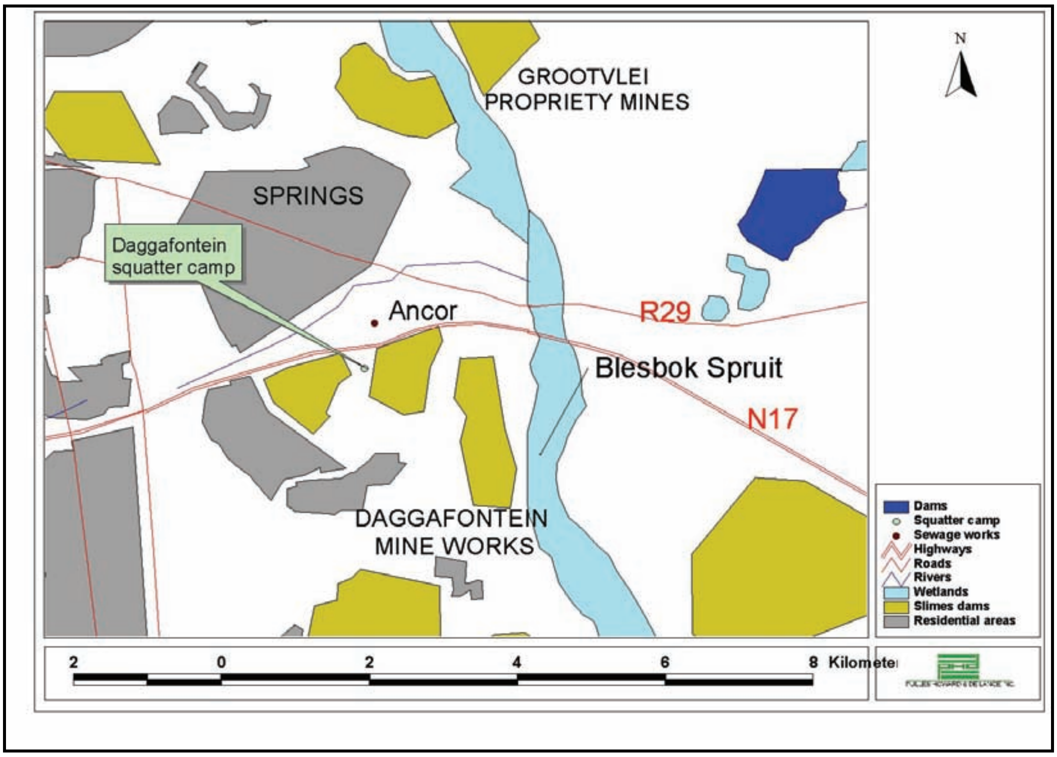


Figure 6.1: Locality map of study area (1:50 000 topographical map)

6.4.2 Current Land Use, Ownership and Population Distribution

The EMM is one of three metropolitan municipalities in Gauteng Province. The area has an estimated population of 2 450 000 people which comprises about 736 000 households (Anon, 2002). This represents about 28 % of the population of Gauteng Province. The EMM is an urban area closely linked to the Greater Johannesburg Metropolitan area that lies directly to the west of it and to the Greater Tshwane Metropolitan area that lies to the north (Figure 6.2). As far as land use is concerned, the EMM comprises three main components (Anon, 2002):

- Residential developments surrounding the industrial activity belt.
- A central, east west orientated mining and industrial activity belt, which served as the core around which 9 towns were established (Figure 6.2).
- Rural/ agricultural areas to the north east and in the central portion to the south of the Metro.

6.4.2.1 Residential

Figure 6.2 indicates the residential townships that occur in the study area including Kwathema, Tsakane and Duduza (Kwatsaduza complex) to the west (24 % of EMM population) and Daveyton and Etwatwa (Daveyton-Etwatwa complex) to the north (12 % of the EMM population). In addition to these residential areas, there are several informal townships or informal settlement communities including the Daggafontein informal settlement. The remainder of the urban complex of the EMM comprises residential areas of middle to high-income communities.

6.4.2.2 Mining

The mining belt in the EMM comprises of three main pockets of mining activity (Figure 2):

- Germiston-Boksburg area
- Benoni-Brakpan-Springs area
- Springs-Nigel area

Mining and mineral beneficiation operations close to the study area include Grootvlei Mine, ERGO and ERGO Brakpan, Consolidated Modderfontein Mines, Knights Gold Mining Company, Impala Platinum Refineries, Zincor and Benoni Gold Holdings.

6.4.2.3 Industry

There are small industrial areas near Springs (Nuffield) and Nigel (Vorsterkroon, Pretoriusstad and Prosperita). Industries that may have an impact on the water quality of the Blesbokspruit include SAPPI, whereas an intensive agricultural operation that may have a negative impact on the water quality is Karan Beef.

In addition to these companies, several sewage works discharge treated effluent into the Blesbokspruit, i.e. the ERWAT sewage works (Ancor, Tsakane, Old Benoni, Rhynfield, Daveyton, Brakpan, JP Marais and McComb sewage works) and the Nigel sewerage works (Bickley and CF Grundling sewage works) also operated by ERWAT.

6.4.2.4 Environment

The most valuable environmental assets of the study area include:

- **RAMSAR site (Blesbokspruit wetland area)**
  The Gauteng Department of Agriculture, Conservation, Environment and Land Affairs (DACEL) regards the RAMSAR site as a wetland that plays an important role in water quality control, especially the polluted water that comes from the mining belt.

- **Public open space below the 1:50 year flood line of the Blesbokspruit**
  In terms of the metropolitan and provincial open space system, the public open spaces along the Blesbokspruit are regarded as extremely important. Some very valuable vlei systems, riparian vegetation and fauna occur in these areas and most of the high sensitivity areas within the study area occur within the 1:50 year flood line.

- **Pans**
  There is an unique occurrence of pans and most of these are regarded as potential bull frog habitats and some sensitive vlei vegetation occurs in and around some of the pans.

6.4.2.5 Agricultural potential

No potential urban agricultural areas have been indicated on the proposed open space plan compiled by the EMM (Anon, 2002). This may be attributed to the fact that these areas and the types of urban agriculture should be determined with the assistance of planners and the involved communities. Only once the type of urban agriculture required and the area (m^2) required have been determined by planners and the involved community, will it be possible to allocate existing open spaces for urban agricultural purposes. One of the research aims of this project is to identify potential agricultural uses for areas in conjunction with the local community.

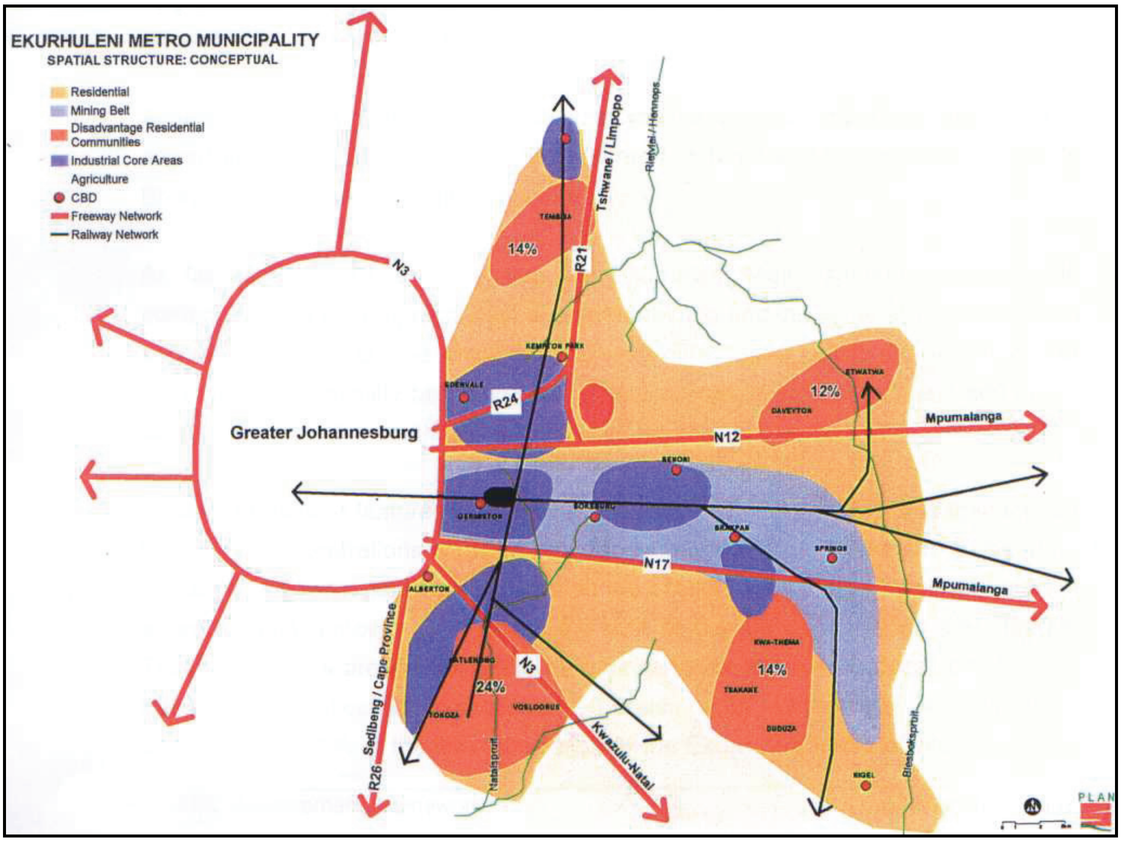


Figure 6.2: Broad land use and population distribution of Ekurhuleni Metropolitan Municipality (Anon., 2002)

6.4.3 Socio-Economic Characteristics

More than 50 % of the population of the EMM is of working age. The official unemployment rate in the EMM area is 38 % (Anon, 2003). The rate of unemployment among females (48.6 %) is higher than among males (30.5 %). About 98 % of all people in the EMM that live below the poverty line are black (Anon, 2002). Mining only contributes 2 % to the economy of the metro and agriculture 1 %.

The regional overview of Ekurhuleni and economic trends and tendencies indicate that the area is characterised by growing unemployment and increasing job losses especially in manufacturing – the primary activity in the area.

According to a study recently completed by the EMM (October 2002), the informal sector in Ekurhuleni Metro is thriving. Informal trade in the central business districts (CBD's) and increasingly around industrial hubs is also evident.

6.4.4 Spatial Development Initiatives In Study Area

6.4.4.1 Roads and transportation

A major shortcoming in terms of the road network is north-south continuity. In particular, there is a need to improve the transportation link between Nigel-Springs-Daveyton.

6.4.4.2 Water Services

Water is a major constraint to future development in the north, north east and the eastern part of the Metro, as well as the central southern part of the Metro. Any development in these areas would require major expansions and/or upgrading of the bulk infrastructure, which would require large capital expenditure (Anon, 2002). In all of the previously disadvantaged areas, there are currently reticulation projects underway. These areas are characterised by large backlogs in services and therefore the reticulation projects are mostly aimed at eradicating these backlogs.

6.4.4.3 Informal settlement and government subsidised housing

The total estimated housing backlog in the EMM area is about 135 000 units of which Nigel comprises 6969 and Springs 8809 houses. Land for 37 000 erven needs to be identified (1400 hectares) in the EMM area.

6.4.4.4 Vacant Land and Land Ownership

Within the urban structure, there is about 30 786 ha of land which is classified as vacant. About 28 % of this land is situated in the eastern region (Nigel-Springs-Brakpan-Daveyton-Tsakane areas), 23 % in the northern region (JIA-Edenvale-Clayville areas) and about 48 % in the southern region (Vosloorus-Katlehong-Alberton areas). This includes land both within and outside the urbanised area.

6.4.4.5 Ekurhuleni spatial development concept and objectives

The EMM has certain development objectives in terms of its spatial structure (Anon, 2002). Certain of these objectives may benefit from the research being undertaken in this WRC-sponsored project. The EMM objectives that may benefit from the current research being undertaken include the following:

- Optimise the food production capacity of the surrounding agricultural areas and to functionally link these areas to the disadvantaged communities in terms of basic food supply, informal trade promotion and SMME development.
- Integrate the disadvantaged communities of the EMM into the urban fabric by way of:

- Infill development on strategically located vacant land
- Promoting corridor development along the main linkages between these communities and the major concentrations of job opportunities.

One of the EMM approaches towards restructuring within its boundaries includes implementing a statutory urban development boundary. Such an urban development boundary will contain urban sprawl and protect the agricultural areas surrounding the urban complex in the Metro. The proposed urban boundary is indicated in Figure 6.3 by a thick blue line (Anon, 2002).

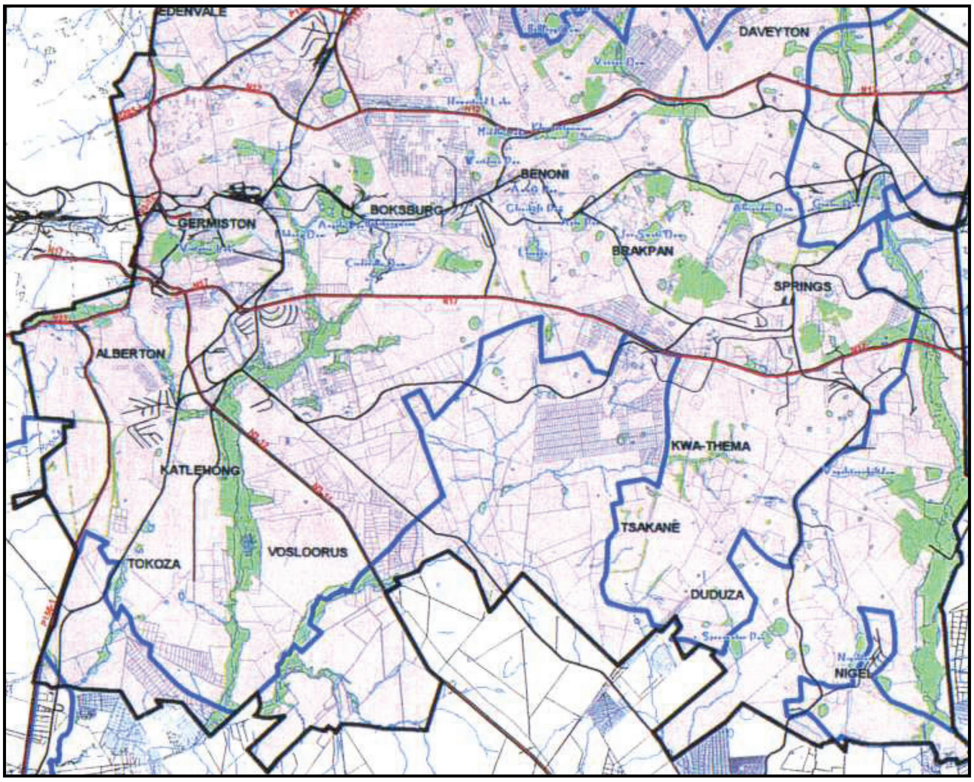


Figure 6.3: Proposed urban development boundary (= areas within thick blue line) (Anon., 2000)

The spatial development framework of the EMM states that land uses that are rural in nature would be more desirable and should be promoted outside the urban edge rather than inside it. **Extensive agriculture** was viewed as a land use that should be allowed in the rural areas outside the urban edge.

The EMM spatial development framework supports the protection of pure agricultural uses in areas earmarked for agriculture and agricultural holdings. This could include intensive and extensive agriculture, subsistence farming, game farming, agri-villages and farm stalls. Supportive land uses, in the form of service centres are promoted in these areas, to give rural communities access to community services and economic opportunities. Areas specifically earmarked for agriculture and agricultural holdings in the study area of this project include:

- Agricultural areas between Daveyton and Springs both inside and outside the urban edge. These areas are constrained by mining.
- Agricultural areas north of the Nigel CBD. These areas are constrained by undermining, but are actively used for agriculture.

6.5 WATER RESOURCES OF THE BLESBOKSPRUIT

6.5.1 Background

The Blesbokspruit is part of the Vaal Barrage catchment and can be divided into two distinct regions, the Upper and Lower Blesbokspruit. The Upper section of the Blesbokspruit is considered to be that portion above the Cowles Dam and has a catchment area of 231 km^2, while the Lower Blesbokspruit catchment area is 1 119 km^2 (SSI, 1997). The Blesbokspruit catchment is situated in the urbanised, mining and agricultural East Rand, in the Springs district, about 3 km east of the town of Springs.

Before mining operations commenced in the early 1930s, the area was typical flat highveld terrain of grassland and crop farming. The Blesbokspruit ran through the area unrestricted with little or no reed beds along its banks. As part of the mining operations, a number of embankments were built across the Blesbokspruit for roads and pipelines, which caused flooding and vast stretches of shallow water were formed, creating one of the few permanent wetlands in Gauteng (SSI, 1997).

Dolomitic aquifers along and adjacent to portions of the upper Blesbokspruit play a role in modifying catchment hydrology due to seepage loss from streams and lakes to underlying aquifers. Erosion of mining slimes dams and subsequent deposition in upper reaches of the Blesbokspruit has led to substantial morphological changes including promotion of the growth of extensive perennially inundated wetland areas that are choked with reed beds, with little riparian habitat diversity. This in turn, is associated with loss of biodiversity and inundation of riparian properties.

A situation analysis that was undertaken for the Blesbokspruit in 1998 (PHD & SSI, 1998) broke the Blesbokspruit down into seven river reaches:

Reach 1 = The upper reach extends from Brakpan to the outflow of Cowles Dam and the users include all the different categories defined by DWAF. The specific industrial water users include Cons. Modderfontein Mine and Sappi; domestic users include informal settlers; and agricultural users consist of irrigation farmers abstracting from the Jan Smuts Dam. Various Water Care Works (WCW), e.g. Jan Smuts, Rhynfield and JP Marais, and mines influence the water quality. Sappi's effluent discharges into the Cowles Dam and is characterised by relatively high salinity (SSI, 1997).
Reach 2 = this reach is defined as the Daveyton branch of the Blesbokspruit north east of Springs. Main water users are domestic (various informal settlements around Daveyton); agriculture (irrigation farmers); recreation and natural environment. The main users negatively impacting on the area are the Daveyton WCW, urban runoff from Daveyton and some small mines in the area. The Holfontein toxic waste site is also located in this reach.
Reach 3 = This reach is defined as the outflow from Cowles Dam to the end of the wetland at the Blesbokspruit Forum sampling point B14 at Nigel. A large wetland that is an internationally recognised Ramsar site dominates the first half of the river channel after the Cowles Dam. The Marievale Bird Sanctuary approximately 1000 ha in extent and about 7.4 ha long, is located in this reach. The main water users are domestic, industrial, agricultural and natural environment. Domestic users include various informal settlements around the river while industrial users include ERGO

mine. Various farmers abstract water from the river and wetland. In this reach, various WCW (McComb and Ancor) and mines influence the water quality. The wetland utilises some of the nutrients imported to the system from the WCWs. Only the Grootvlei Gold Mine discharges underground water into the Blesbokspruit (SSI, 1997).
Reach 4 = this reach is defined from Nigel to the Blesboksspruit Forum sampling point B19 at Heidelberg. The main water users in this section are agriculture, recreation and natural environment.
Reach 5 = this reach consists of the Blesbokspruit from Heidelberg to the confluence with the Suikerbosrand River.
Reach 6 = this reach is defined as the Suikerbosrand River upstream of the confluence with Blesbokspruit.
Reach 7 = this reach is defined as that section of the Blesbokspruit from its confluence with the Suikerbosrand River to the confluence with the Vaal River.

As far as this research project is concerned, the area and infrastructure located within Reach 3 is the most relevant to this project.

6.5.2 Water Users

The following users of the Blesbokspruit are affected by discharges to the system:

- Blesbokspruit wetland system (Ramsar Site)
- Riparian irrigation farmers
- Landowners subject to increasing inundation and encroachment of reeds due to continuous expansion of man-made wetland system.

The five water user groups specified by the Department of Water Affairs and Forestry (DWAF) are agriculture, industrial, the wetland and aquatic ecosystem and recreation:

6.5.2.1 Agriculture

Approximately 62.3 km^2 of land is allocated to agricultural use. The eastern and some southern parts of the Blesbokspruit catchment is dominated by prime agricultural land in the form of smallholdings that cultivate predominantly maize, wheat and vegetables. Sheep and cattle farming is also present on a small scale (SSI, 1997). The Upper and Lower Blesbokspruit has 1 000 and 10 000 ha under irrigation respectively (DWAF, 1995). In an assessment of the implications of dewatering the East Rand Basin into the Blesbokspruit it was concluded that there was a high risk of long term soil salination on many of the lands irrigated with water from the Blesbokspruit if dewatering went ahead (WEC, 1995). There is also a potential risk of heavy metal poisoning to livestock drinking the mine water mix in the Blesbokspruit.

6.5.2.2 Mining

The impacts of industrial users on the Blesbokspruit are potentially significant. Significant mining activities are found in the areas south and south east of Springs. These include Grootvlei, Geduld and Daggafontein mines. The underground workings of many mines in the East Rand lie at the base of a natural groundwater drainage system, into which groundwater slowly gravitates. It has been the usual practice for the mines to abstract groundwater from working areas and discharge it to the surface, thereby controlling the relative groundwater levels through the catchment.

As mining operations in the East Rand have progressively stopped their groundwater abstraction practices, mainly through closure, the relative groundwater volumes arriving and accumulating at Grootvlei (lowest position in the drainage system) have increased. Dewatering at Grootvlei has become necessary in order to maintain the groundwater balance in the underground basin (SRK, 1997). Thus, Grootvlei Proprietary Mines discharges directly into the Blesbokspruit approximately 110 Mℓ/day (with quite wide variance depending on season), making it the largest polluter of the Blesbokspruit, with high salinity levels that are cause for concern.

6.5.2.3 Industrial

Several industries are located in the Blesbokspruit area including the Sappi Enstra Mill, Dunswart, Zincor, etc. One of the industries that impact the most on the Blesbokspruit is the Water Care Works (WCW) of which seven are situated in the Blesbokspruit catchment. These sewage treatment works have an impact on the surface water systems in the Upper Blesbokspruit.

6.5.2.4 Wetland and Aquatic Ecosystem

The Blesbokspruit wetland system was designated as a Ramsar site on 2nd October 1986. The mismanagement of a Ramsar site may have international diplomatic repercussions. Wetlands are known for their water treatment capabilities and a number of studies on the Blesbokspruit have highlighted its purification abilities. The economic importance of the system should therefore not be overlooked. In the 20-km of river length, significant quantities of suspended solids and heavy metals are removed from the Blesbokspruit. The correct management and conservation of the wetland, which enables it to function in a viable way, is therefore very important.

6.5.2.5 Recreation

The Blesbokspruit offers recreational opportunities in terms of birding. The ERWAT WCW site would reduce nutrient loads because lower discharges in the area would have a beneficial effect for recreational users by reducing the size of congested hydrophyte stands.

6.5.3 Discharge Standards

The Blesbokspruit Forum has compiled in-stream water quality guidelines for this catchment (Table 6.1) that are described as Ideal (catchment background), Acceptable (management target), Tolerable (interim target) and Unacceptable (Unacceptable). These in-stream water quality guidelines are noted and will be used as the objectives that individual dischargers must be comply with and that will be used in this study.

6.5.4 Water Licences And Permits

Grootvlei Mine has a water use licence issued by DWAF, while ERWAT has a water permit. Water permits are pending for Sappi and the ITC (discharge to Cowles Dam).

Table 6.1: In-stream water quality guidelines for the Blesbokspruit Catchment

IN STREAM WATER QUALITY GUIDELINES FOR THE BLESBOKSPRUIT CATCHMENT					
Variables	**Measured as**	**Ideal** **Catchment background**	**Acceptable** **Management Target**	**Tolerable** **Interim Target**	**Unacceptable** **Unacceptable**
Physical					
Conductivity	mS/m	< 45	45-70	70-120	> 120
Dissolved Oxygen	mg/ℓ O_2		> 6.0	5.0-6.0	> 6.0
$_p$H	$_p$H units	6.5-8.5			< 6.5 and > 8.5
Suspended Solids	mg/ℓ	< 20	20-30	30-55	> 55
Organic					
Chemical Oxygen Demand	mg/ℓ	< 20	20-5	35-55	> 55
Macro Elements					
Aluminium	mg/ℓ		< 0.3	0.3-0.5	> 0.5
Ammonia	mg/ℓ	< 0.1	0.1-1.5	1.5-5.0	> 50.
Chloride	mg/ℓ	< 80	80-150	150-200	> 200
Fluoride	mg/ℓ	< 0.19	0.19-0.70	0.70-1.0	> 1.0
Iron	mg/ℓ	< 0.1	0.1-0.5	0.5-1.0	> 1.0
Magnesium	mg/ℓ	< 8	8-30	30-70	> 70
Manganese	mg/ℓ	< 0.2	0.2-0.5	0.5-1.0	>1.0
Nitrate	mg/ℓ	< 0.5	0.5-3.0	3.0-6.0	> 6.0
Phosphate	mg/ℓ	<0.2	0.2-0.4	0.4-0.6	>> 0.6
Sodium	mg/ℓ	< 70	70-100	100-150	> 150
Sulphate	mg/ℓ	< 150	150-300	300-500	> 500
Bacteriological					
Faecal coliformes	Counts/100 mℓ		< 126	126-1 000	> 1000
Biological					
Daphnia	% survival	100	90-100	80-90	< 80

6.6 WATER QUALITY REQUIREMENTS

6.6.1 Background

Grootvlei Mine discharges directly approximately 70-120 M/ℓ water/day into the Blesbokspruit. This water has high salinity levels, which is cause for concern. Similarly, the ERWAT sewage treatment works are also one of the major polluters of the Blesbokspruit as they also discharge treated effluent directly into the Blesbokspruit. A water treatment initiative, Rhodes University's BioSURE® treatment process, using sewage sludge from ERWAT and mine water from Grootvlei has been applied to the water to improve the quality before discharging it to the Blesbokspruit. However, the objective of this study is to co-treat saline and sewage wastewaters by applying a biotechnological process.

6.6.2 Dilution Calculation

The water treated by the biotechnological process will be discharged into the Blesbokspruit. It is assumed that the treatment will reduce the sulphate concentration to acceptable levels of 100 mg/ℓ. However, sodium and chloride values may exceed acceptable levels. It is estimated that treated water will have a sodium concentration of 240 mg/ℓ and a chloride concentration of 180 mg/ℓ. Since the capacity of the treatment plant is 10 Mℓ/day, this value will be assumed as the volume that will be discharged into the Blesbokspruit.

By mixing the treated discharge with effluent from Ancor and Welgedacht Sewage Works, the sodium and chloride values may become diluted to acceptable values. Both these sewerage works discharge approximately 30 Mℓ/day respectively. The following calculation was used to determine the quality of the mixed water:

A: Mixing with effluent from Ancor Sewerage Works

{(QT x 10 Mℓ/day) + (QA x 30 Mℓ/day)}/ 40 Mℓ/day

B: Mixing with effluent from Ancor and Welgedacht Sewerage Works

{(QT x 10 Mℓ/day) + (QA x 30 Mℓ/day) + (QW x 30 Mℓ/day)}/ 70 Mℓ/day

Where

QT = Quality of treated water
QA = Quality of Ancor Sewage Works effluent
QW = Quality of Welgedacht Sewage Works effluent

The results of the mixed water will determine whether the quality is suitable to be discharged into the Blesbokspruit without further treatment to reduce the salt concentration. The water quality guidelines set for the Blesbokspruit are indicated in Table 6.1.

Table 6.2 shows the calculated water quality for variables of concern (SO_4, Na and Cl) when the treated water is mixed with the effluent from Ancor Sewage Works. Mean values for the period January 2003 to March 2003 were used.

Table 6.2: Calculated water quality when the treated water is mixed with the effluent from Ancor Sewage Works.

Variable	Discharge after Biosure treatment	Discharge from Ancor	Quality of mixed water
Sulphate (mg/ℓ)	100	106.2	105
Sodium (mg/ℓ)	240	73.9	115
Chloride (mg/ℓ)	180	80.0	105

Comparing the calculated quality (Table 6.2) with the guidelines (Table 6.1) the following observations are made:

- Sulphate concentration stays below the ideal value.
- The unacceptable sodium concentration is diluted to **Tolerable** by mixing with effluent from Ancor Sewage Works.
- Chloride concentration is tolerable before mixing and **Acceptable** after mixing with effluent from Ancor Sewage Works.

Table 6.3 shows the calculated water quality when the treated water is mixed with the effluent from both Ancor and Welgedacht Sewage Works. Mean values for the period January 2003 to March 2003 were used for the Ancor effluent, while mean values for the period January 2003 to July 2003 were used for the Welgedacht effluent.

Table 6.3: Calculated water quality when the treated water is mixed with the effluent from both Ancor and Welgedacht Sewerage Works

Variable	Discharge after Biosure treatment	Discharge from Ancor	Discharge from Welgedacht	Quality of mixed water
Sulphate (mg/ℓ)	100	106.2	96.8	101
Sodium (mg/ℓ)	240	73.9	82.5	101
Chloride (mg/ℓ)	180	80.0	66.1	88

Comparing the calculated quality (Table 6.3) with the guidelines (Table 6.1) the following observations are made:

- Sulphate concentration stays below the ideal value.
- The unacceptable sodium concentration is diluted to **tolerable** by mixing with effluent from Ancor and Welbedacht Sewage Works. The value is just above the limit for acceptable water quality (100 mg/ℓ).
- Chloride concentration is tolerable before mixing and **acceptable** after mixing with effluent from Ancor and Welbedacht Sewage Works.

This indicates that mixing water from the BioSURE® treatment plant with effluent from Ancor and Welgedacht Sewerage Works before discharging to the Blesbokspruit will ensure tolerable water quality.

6.7 CURRENT WATER QUALITY IN BLESBOKSPRUIT

At present, the following organisations run water quality monitoring programmes that cover substantial portions of the Blesbokspruit catchment:

Department of Water Affairs and Forestry (DWAF) Gauteng Regional office
DWAF Directorate: Hydrology
Rand Water
ERWAT

Some Local Authorities run monitoring networks and/or carry out ad hoc sampling in their areas of jurisdiction. Some industries also monitor water quality near their operations. Much of the water quality sampling carried out by these organisations is done to comply with their permit/licence conditions.

The water quality monitoring points along the Blesbokspruit that are measured by DWAF and Rand Water are listed in Table 6.4 and indicated in Figure 6.4.

Table 6.4: Water quality monitoring points along the Blesbokspruit

DWAF Name	Rand Water name	Description
C2H134	B9	Cowles Dam outflow at Springs
C2H150		Welgedacht Slime Dam R555 Bridge on Blesbokspruit
	B5	Blesbokspruit at Welgedacht
C2H143		Grootvlei Mine Retention Dam Discharge Point
C2H142	B16	At Grootvlei Shafts 3 & 6 Bridge Blesbokspruit
	B15	Blesbokspruit at N17 Bridge
C2H146		Daggafontein 2 km downstream of N17 on Blesbokspruit
	B17	Blesbokspruit at Marievale Bird Sanctuary

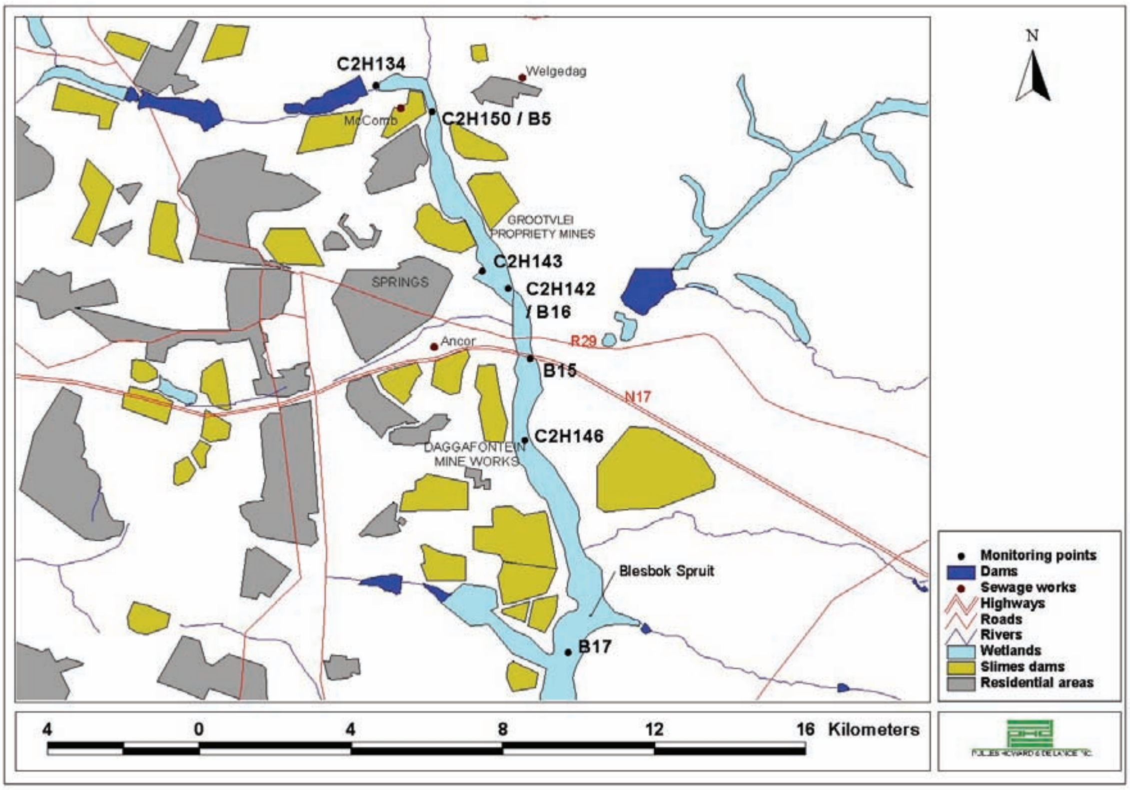


Figure 6.4: Water quality monitoring points located along the Blesbokspruit.

Figure 6.5 indicates the water quality data at selected monitoring points along the Blesbokspruit. The data used include long term mean values as supplied by DWAF and mean values for 2001 to 2003 for selected Rand Water sites (Table 6.5).

Table 6.5: DWAF monitoring periods for selected monitoring points.

Site		Start	End
DWAF	C2H134	10-Nov-93	19-Dec-02
DWAF	C2H142	05-Jan-96	13-Jan-97
DWAF	C2H143	05-Jun-96	19-Feb-97
DWAF	C2H146	05-Jun-96	21-Jun-99
DWAF	C2H150	14-Nov-91	26-Mar-03
RAND WATER	All sites	April 2001	March 2003

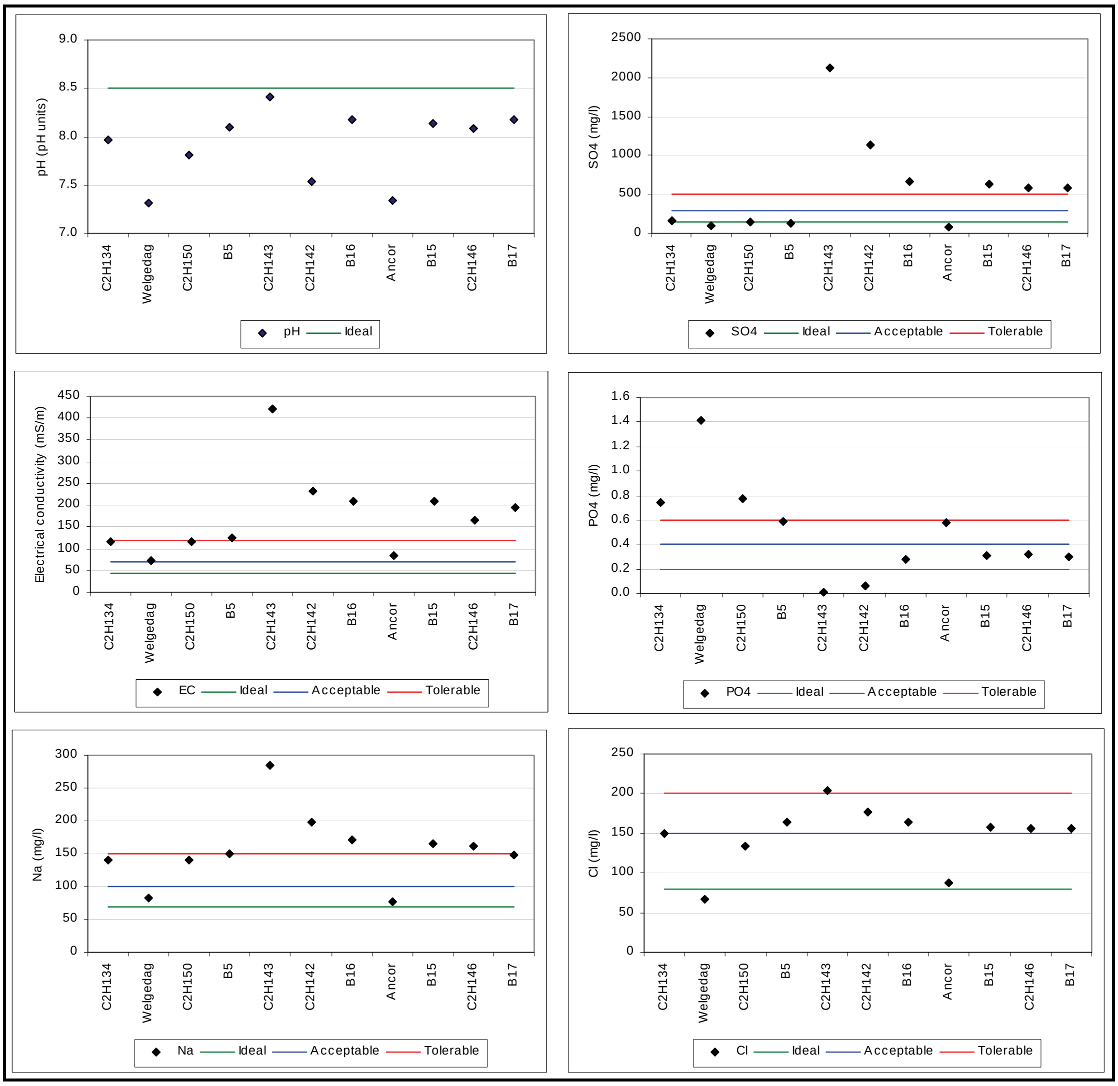


Figure 6.5: Water quality data for monitoring points along the Blesbokspruit

The following trends are observed from the data in Figure 6.5:

- C2H143 at the Grootvlei retention water dam discharge point shows poor water quality with values of sulphate, electrical conductivity, sodium and chloride at unacceptable levels. In general the water quality improves downstream of this point.
- Phosphate concentrations are unacceptable for Welgedacht effluent, C2H134 and C2H150 and tolerable for B5.
- pH is high, but within guideline limits.
- Except for the Ancor effluent, the electrical conductivity, sulphate and sodium concentrations are unacceptable for all monitoring points downstream of C2H143.
- Chloride concentrations are unacceptable for C2H143, tolerable for C2H142, C2H146 and B17 and acceptable for the other monitoring points. The Welgedacht sewerage effluent has ideal chloride concentrations.

Table 6.6 is a broad summary of the pollution inputs into the Blesbokspruit.

Table 6.6: Pollution inputs to the Blesbokspruit

Pollutant	**Surrogate variable**	**Impacted User**	**Impacters**
Salinity	EC	Livestock / domestic	Mines / Industry / sewage treatment works
Bacteria / viral	Faecal coliform	Domestic (informal settlements) / dairy / cattle / recreation / natural environment	Sewage Treatment works / urban runoff
Metals	Fe, Mn, etc.	Domestic / natural environment / livestock and irrigation	Mining / Industry
Nutrients	PO_4	Natural environment / recreation / irrigation / livestock.	Sewage treatment works / Urban runoff
Ammonia	NH_4	Natural environment	Sewage treatment works / Mining / industry
SS	SS	Natural environment / recreation	
Organics	COD	Natural environment / recreation	

The data in Figure 6.5 indicates that catchment development has led to deterioration in water quality. The salinisation of water resources in the Blesbokspruit catchment may be broadly summarised as being attributable to:

Mining pollution – de-watering of underground workings by Grootvlei gold mine and diffuse wash-off from numerous mine dumps, seepage from abandoned coal mining areas and activities associated with the recovery of gold from old slimes dams, notably ERGO and Knights.

Industrial pollution – point discharge from SAPPI Enstra pulp and paper factory and general diffuse wash-off from industrial areas

Treated sewage effluent – water care works run by ERWAT and Nigel

Urban run-off – from Benoni, Springs, Daveyton, Nigel, Tsakane, Heidelberg and Ratanda

Irrigation return flow – from lands irrigated with industrial effluent by Sappi and from riparian irrigation farmers.

6.8 SPATIAL DEVELOPMENT PLAN

One of the aims of this project is to identify an area that is suitable for the establishment of a large-scale agricultural initiative that would utilise the water treated by the Biotechnology process.

6.8.1 Extent of Required Agricultural Land

Based on the availability of water from the Blesbokspruit (Rose, 2003, *pers. comm.*) and the volumes of water required for running a hydroponics operation; the surface area of the agricultural land that is required for utilising the excess water may be calculated as follows:

Available water = 100 Mℓ/day.

Water required by hydroponics = 50 000 ℓ/ha/day.

Therefore 2 000 ha of land is required to utilise the available water. Information from 1:50 000 topographical maps indicates that at least 2600 ha are available for development (Figure 6.6). It is recommended that the area be ground-truthed to verify this information obtained from maps.

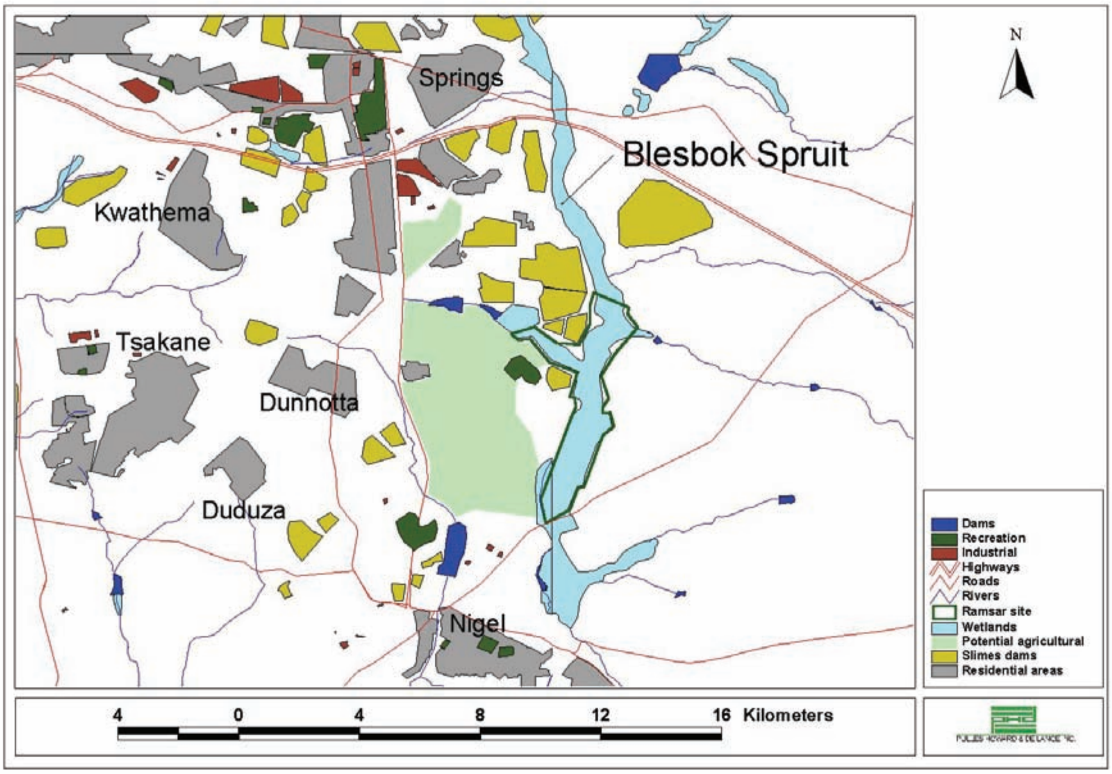


Figure 6.6: Areas of potential agricultural development

6.8.2 Potential Area Identified

The potential area that has been identified during this study in the Ekurhuleni Metropolitan area is rectangular in shape and is currently zoned as primary open space (Anon, 2002). It has the N17 highway as its northern boundary, the Blesbokspruit River as its eastern boundary, the town of Nigel as its southern boundary and the R51 Road as its western boundary (Figure 6.6). This area includes an abandoned aerodrome, reclaimed mine dumps, pans, residential areas, cultivated lands, wetland areas associated with the Blesbokspruit and brick works.

6.8.3 Recommendations

The following issues should be noted during the final area selection process:

DACEL Buffer Zone Policy – when selecting the area, the DACEL buffer zone policy must be noted. DACEL have compiled an internal buffer zone policy document which places restrictions on proposed developments in close proximity to mining areas, sewerage plants, etc. The proposed DACEL buffer zones could have a significant impact on the sizes of developable land and the types of land uses that will be allowed adjacent to the buffer zones. DACEL should be afforded an opportunity to comment on developments within the Spatial Development Framework, as this buffer zone document could place a limit on the development potential of the study area.

Effect of agriculture on environment – although conventional commercial urban agriculture has a high social and economic value, i.e. capacity building, environmental education and economic upliftment; it does not necessarily have a high ecological value. In many cases, the agricultural activity could have a significant detrimental effect on the qualitative, physical and biophysical environment, i.e. over irrigation, water pollution by fertilisers, etc.

Use of water for agricultural purposes – Although the aim of this research is to look at the establishment of hydroponic ventures, community gardens may also be established. The quality of the treated water must be monitored and if it is saline, it should only be used in well-drained soils, with salt tolerant plants.

7. WATER QUALITY, SOIL AND CLIMATE

JP Nell
Institute for Soil Climate and Water
Pretoria

7.1. TERMS OF REFERENCE

The Institute for Soil, Climate and Water (ISCW) was approached by Petrex (Pty) Ltd to do a pre-feasibility study on the effect of water quality and climatological factors on crop production in a possible irrigation project near the Blesbokspruit, and utilising treated water from the Grootvlei Desalination Project. In addition to reverse osmosis (RO) treated water from the Rhodes BioSURE Process® was to be considered.

The study was to focus on the possibilities and constraints of the physical environment and water qualities by taking the following aspects into account:

- Characteristics and suitability of the climate
- Climatically adapted crops
- Influence of three different water qualities on the kinds of crop that can be grown in the study area

7.2 INTRODUCTION

All soils contain some water-soluble salts. Plants absorb essential nutrients in the form of soluble salts, but excessive accumulation of soluble salts, called soil salinity, suppresses plant growth. As plants absorb soil water or as water evaporates, salts from the water remain in the soil. For this reason, soil salinity will usually be greater than the salinity of the irrigation water used. Improper irrigation management increases the risk of developing soil salinity.

The general effect of soil salinity on plants is called an osmotic effect. This means that salts increases the energy with which water is held in the soil. In other words, the soil must be kept wetter to supply the same amount of plant-available water as would be present without the salts (the osmotic effect for NaCl is about 2.5 to 3 times higher than the osmotic effect for $CaSO_4$). Plants must then increase the energy they expend to obtain water from the soil. The plant must use energy to get water that would otherwise be used for growth, flowering, or fruiting. When soil salinity exceeds a plant's tolerance (threshold value), growth reduction occurs. As salt concentration increases, water becomes increasingly difficult for the plant to absorb. A plant can actually die from water stress or drought in a moist soil if the salt concentration becomes high enough. Plants vary in their response to soil salinity. Salt-tolerant plants (plants less affected by salinity) are better able to adjust internally to the osmotic effects of high salt concentrations than salt-sensitive plants.

Other effects of salts on plants are toxicities of specific salts and nutritional imbalances. Some elements, such as Na, Cl and B, have specific toxic effects on plants. Plants sensitive to these elements may be affected at relatively low salt levels if the soil contains enough of the toxic element. Because many salts are also plant nutrients, high salt levels in the soil can upset the nutrient balance in the plant or interfere with the uptake of some nutrients.

Crops need to be identified which would, due to their genetic characteristics, be adapted to the given climate, water quality and soil conditions. Over time, a balance tends to be established between dissolved salts, which may be present in the irrigation water and the salt content of the soils. This balance can be altered to a degree by the presence or absence of leaching if the soils are sufficiently permeable. The tolerance of crops to harmful salts or elements taken up through the roots or through the leaves thus needs to be thoroughly taken into account.

7.3 METHODOLOGY

7.3.1 Climate Study

The same data set used by Schoeman *et al.* (1995) was also used in this study. This databank contains climate data collected by various organisations, including the Agricultural Research Council and the South African Weather Bureau.

7.3.2 Identification Of Climatologically Adapted Crops

Critical climate data with respect to the study area was made available to crop specialists of the Vegetable and Ornamental Plant Institute as well as the Institute for Tropical and Subtropical Crops, both Institutes of the Agricultural Research Council (ARC). They were requested to compare climatic requirements of crops, as can be gleaned from the literature and from South African experience, with climate data of the study area in order to compile lists of climatically adapted crops.

The Food and Agricultural Organization's Crop Environmental Requirements Database (ECOCROP 1, FAO, 1994), containing information on 1 200 crops as well as work done by Ehlers (1988) were both examined in order to identify suitable crops.

7.3.3 Water Quality

For purpose of this study water quality analyses were provided by Petrex (Pty) Ltd and ERWAT Water Care Company.

A leaching fraction (LF) of 0.20 was taken as basis for calculation of potential crop loss for a sandy soil and 0.10 for the higher clay content soil. The following relationship between LF, electrical conductivity of the water (EC_w), electrical conductivity of the soil extract (EC_e) and potential crop loss (Rhoades and Merrel, 1975) was used to calculate potential crop loss:

$$LF = \frac{0.2\ EC_w}{EC_e - 0.2\ EC_w} \quad \text{(Equation 1)}$$

Calculation of potential crop loss was done as follows:

For carrots, for example, the following is given:
$EC_w = 250\ mS\ m^{-1}$ (water analyses)

LF = 0.20 (experimentally determined; from literature)
EC_e = 300 mS m^{-1} (calculated by means of Equation 1)
Threshold EC_e = 100 mS m^{-1} (experimentally determined; from literature)
Slope = 0.14 (experimentally determined; from literature)

An EC_e value of 300 exceeds the threshold by 200 mS m^{-1}. The slope of 0.14 means that for each one mS m^{-1} that EC_e exceeds the threshold, one percent crop loss is expected to take place. 200 times 0.14 then gives an expected crop loss of 28%.

7.3.4 Effect Of Water Quality On Crop Production

In the evaluation of potential effects of water quality on crop production under irrigation, the following three aspects were taken into account:

- *Crop yield*: The effect on profitability (crop selection, crop yield and crop acceptability) is the main criterion to be used in determining the suitability of irrigation water
- *Soil degradation:* The suitability of irrigation water needs to be determined by the degree to which the water quality influences soil degradation and the sustainability of production
- *Management options:* The degree to which different management options (e.g. leaching, night irrigation and blending of water) need to be employed to alleviate undesirable effects was taken into account.

Water quality constituents were evaluated in respect of the following effects**:**

- *Salinity:* Irrigation with saline water induces soil salinity (measured as the electrical conductivity of the saturation extract from a soil sample from the root zone, EC_e). The threshold value, as well as the rate at which crop loss increases once the threshold is exceeded (called the slope) has been experimentally determined for the more common crops of the world. Published threshold and slope values are used when available (Ayers and Westcott, 1985; Maas, 1990).
- *Sodicity:* Irrigation with sodic water induces soil sodicity which results in reduced soil permeability and a reduced infiltration rate through the process of surface sealing.
- *Toxic effects:* Ions are viewed as toxic to plant growth when they cause crop damage or reduced yield at concentrations which are lower than would be expected from their relative contribution to total salinity (Department of Water Affairs and Forestry, 1993). The ions of primary concern in the present study are chloride and sodium.

7.4 RESULTS

7.4.1 Climatologically Adapted Crops

Crops, which were considered to have a high probability of being able to be grown in the area, are listed in Table 7.1. In the table, the main reason for a crop to be rated sub-optimal, marginal or not recommended is given in brackets (e.g. T_H that means that the crop needs higher temperatures than those of the study area). In the column for growing season, S indicates that the particular crop grows mainly during the summer season and W that the crop is genetically adapted to grow also during the winter season.

Table 7.2 shows the sensitivity of crops to irrigation water salinity. Threshold conductivity values of the soil saturation extract (EC_e) at which crop loss will take place in the long term if no leaching is allowed for, are given when available. Where no published experimental data are available, the rating given in the ECOCROP database (FAO, 1994) is indicated.

The rate (slope) at which crop loss is expected to increase with increasing EC_e, is given when available. Where no published experimental data are available, values were derived by means of a regression equation.

The table shows, firstly, that there is a dearth of experimental information on crop salt tolerance. The potential crop loss due to salinity could not be calculated for a large number of crops.

The crops that are currently being grown under irrigation in the Blesbokspruit catchment include beetroot, beans, broccoli, Brussels sprouts, cabbage, carrot, cauliflower, celery, chives, lettuce, morog, onion, pea, radish, spinach, kikuyu grass, lucerne, maize, potatoes and wheat.

Note 1 Where published EC_e values are unavailable, the rating given in the ECOCROP database (FAO, 1994) is used, where L denotes low (EC_e <400 mS m^{-1}), M moderate (400-1000 mS m^{-1}) and H high threshold values (>1000 mS m^{-1}). Unsure ratings are indicated by lower case.

TABLE 7.1: CROPS CONSIDERED RELEVANT TO THE STUDY AREA

COMMON NAME	BOTANICAL NAME	CLIMATE SUITABILITY	GROWING SEASON	KILLING TEMPERATURE	REMARKS
HERBS, SPICES, MEDICINAL AND INDUSTRIAL CROPS					
Camomile	*Anthemis nobilis*	Sub-optimal (F)	S	Frost in spring	Perennial herb; economic life 3-4 years
Common liquorice	*Glycyrrhisa glabra*	Not rec. (T_H)	S;T	Frost	Perennial herb; harvest in 3-5 years
Coriander	*Coriandrum sativum*	Optimal	S	-10^o C	Annual herb; mature seeds in 80-140 days
Corn mint	*Mentha arvensis*	Sub-optimal (D_L)	S	Below freezing	Perennial herb growing for 5-6 years
Dandelion	*Taraxacum officinale*	Optimal	S;W	Low	Perennial herb
Digitalis	*Digitaria purpurea*	Not rec. (T_H)	S;T	Frost	Perennial or biennial herb; leaves collected from 2 years onwards
Endive	*Cichorium endiva*	Optimal	S	-5^o C	Annual/biennial herb; growing seas. 70-85 d
Fennel	*Foeniculum vulgare*	Optimal	S	-2^o C	Perennial/annual herb; life expectancy 4-5 y
Garlic	*Allium sativum*	Optimal	S;W	-5^o C	Biennial/annual; growing season 90-120 d
Ginger	*Zingiber officinale*	Not rec. (T_H)	S;T	0^o C	Perennial herb grown as annual; harvest after 270-365 days
Parsley	*Petroselinum crispum*	Optimal	S	-5^o C	Biennial: leaves harvested after 70-100 days and through season
Peppermint	*Mentha x piperita*	Optimal	S;W	-8^o C	Perennial herb; first shoots harv. 40-55 d

Pirethrum	Pirethrum	Optimal	S;W	Low	Half-hardy perennial herb; annual in temperate regions; 180-240 days growing season
COMMON NAME	**BOTANICAL NAME**	**CLIMATE SUITA-BILITY**	GROWING **SEASON**	**KILLING TEMPERATURE**	REMARKS
Rosemary	*Rosmarinus officialis*	Marg. (T_H)	S	-5 ° to -15 ° C	Evergreen perennial shrub; treated as annual
Safflower	*Carthamus tinctorius*	Marg. (T_H)	S	2-7 ° C	Annual; 120-160 days
VEGETABLE CROPS					
Asparagus	*Asparagus oficinalis*	Optimal	S;W	-5 ° C	Perennial herb with annual stems; growing season per year 270-300 days
Beetroot	*Beta vulgaris*	Sub-optimal(D_L)	S;W	Low	Biennial herb, grown as annual; 55-90 days
Bean	*Phaseolus vulgaris*	Optimal	S	0 ° C	Annual; fresh beans within 50-90 days
Broad bean	*Vicia faba*	Optimal	S;W	-10 ° C	Annual; fresh beans within 120-150 days
Broccoli	*Brassica oleracea*	Optimal	S;W	0 ° C	Growing season 80-120 days
Brussel sprouts	*Brassica oleracea gemmifera*	Optimal	S;W	-5 ° C	Annual herb; growing season 100-130 days
Cabbage	*Brassica oleracea capitata*	Optimal	S;W	-10 ° C	Annual; heads harvested after 80-110 days
Carrot	*Daucus carota*	Optimal	S	-1.5 ° C	Annual; baby car. 60-80 d.; full size 70-150 d
Cauliflower	*Brassica oleracea botrytis*	Optimal	S;W	-5 ° to -10 ° C	Annual; harvested after 60-120 days
Celery	*Apium graveolens*	Optimal	S	-5 ° C	Annual; harvested after 80-160 days
Chard	*Beta vulgaris*	Sub-optimal(D_L)	S;W	Unknown	Perennial; 50-60 days to first harvest

Chicory	*Cichorium intybus*	Sub-optimal(T_HD_L)	S	-5° C	Perennial herb
COMMON NAME	**BOTANICAL NAME**	**CLIMATE SUITABILITY**	**GROWING SEASON**	**KILLING TEMPERATURE**	**REMARKS**
Chinese cabbage	*Brassica pekinensis*	Not recom. (T_H)	S	0° C	Annual; harvested after 50-90 days
Chives	*Allium schoenoprasum*	Optimal	S	Frost resistant	Perennial herb; harvested after 70-100 days; replanted 2-3 years
Collard	*brassica oleracea*	Optimal	S	-5° C	Perennial/ annual; harv. 60-120 days
Cucumber	*Cucumis sativus*	Marginal (T_H)	S;T	Frost resistant	Annual; growing season 40-180 days
Dill	*Anethum graveolens*	Optimal	S	Frost resitant	Annual/biennial herb; 150-180 days for seed production; leaves harvested when mature
Clobe artichokes	*Lynara scolysum*	Optimal	S	1° C	Perennial herb; 3 years to top production
Horseradish	*Armoracia rusticana*	Optimal	S	-5° C	Perennial herb; grown as annual
Kohlrabi	*Brassica oleracea gongylode*	Optimal	S	Frost resistant	Biennial; grown as annual; harvested 50-70 days from transplanting
Leek Lettuce	*Allium porrum* *Lactucea sativa*	Optimal Optimal	S S	Frost resistant -6° C	Biennial; grown as annual; 12-150 days Annual; 60-85 days
Morog (African spinach)	*Amaranthus spp*	Optimal	S	4° C	Short lived annual; 30-50 days to first harvest; growing season 120-300 days
Onion	*Allium cepa*	Optimal	S;W	0° C	Annual; 85-175 days
Parsnips	*Pastinaca sativa*	Optimal	S	Frost resistant	Biennial; harvested 80-150 days
Pea	*Pisum sativum*	Optimal	S;W	-2° C	Annual; 60-100 days (green peas)

Pumpkin	*Curcubita maxima/pepo*	Sub-optimal (T_H)	S	0 C	Annual; 80-140 days
COMMON NAME	**BOTANICAL NAME**	**CLIMATE SUITABILITY**	**GROWING SEASON**	**KILLING TEMPERATURE**	**REMARKS**
Radish	Raphanus sativus	Optimal	S	-5° C	Annual; ready for harvest after 22-50 days
Rhubarb	*Rhuem rhabarbarum*	Optimal	S	Moderately hardy	Perennial; harvest after 2 years
Salsify	*Tragopogon porrifolius*	Optimal	S	Moderately hardy	Biennial herb; grown as annual
Spinach	*Spinacia oleracea*	Optimal	S	-7° C	40-70 days to harvest
Squash zucchini	*Cucurbita maxima*	Marginal (T_H)	S;T	0° C	Annual; 40-100 days to harvest
Strawberry	*Fragaria anamassa*	Optimal	S	Moderately hardy	Perennial harv. 180-270 days from planting
Tomato	*Lycopersicon esculentum*	Marginal (T_H)	S;T	0° C	70 -130 days to harvest
Turnips	*Brassica rapa*	Optimal	S;W	-10° C	Biennial/annual
PERENNIAL FRUIT, BERRY AND NUT CROPS					
Apricot	*Prunus armeniaca*	Sub-optimal (T_H)	S	-1.5° C	Perennial deciduous tree
Black currant	*Ribes nigrum*	Optimal	S	Full bless -1° C	Perennial shrub; harv. 2 years; econ. life 20y
Black raspberry	*Rubus occidentalis*	Optimal	S	-29° C	Perennial shrub; fruit from 5-10 years
Cranberry	*Vaccinium macrocarpon*	Optimal	S	-5° C	Perennial vine
Dewberry	*Rubus spp*	Sub-optimal (T_L)	S	Unknown	Perennial herb
European gooseberry	Ribes uva-crispa	Sub-optimal (T_L)	S	-28° C	Perennial shrub
Grape	*Vitis vinifera*	Sub-optimal (T_H)	S	Dormant: -12 C	Perennial vine

COMMON NAME	BOTANICAL NAME	CLIMATE SUITABILITY	GROWING SEASON	KILLING TEMPERATURE	REMARKS
Kiwi fruit	*Actinidia chinensis*	Sub-optimal (T_H)	S	Growing:-1.5 ^{o} C Dormant: -9 ^{o} C	Perennial Deciduous vine; full season after 8-10 years; long life
Mulberry	*Morus nigra*	Sub-optimal (T_H)	S	-5 C	Deciduous tree; bearing within 1-2 years; economic life 10-25 years
Peach	*Prunus persica*	Optimal	S	Flowering: -1 ^{o} C	Deciduous tree
Pecan nut	*Carya illinoiensis*	Sub-optimal (T_H)	S	-20 ^{o} C; long frost-free season	Perennial Deciduous tree; bear after 4-5 years; long life
Pistacio nut	*Pistacia vera*	Sub-optimal (T_H)	S	-18 ^{o} C	Perennial Deciduous tree
Plum	*Prunus domestica*	Optimal	S	Pods: -5 ^{o} C; winter hardy	Deciduous tree
Quince	*Cydonia oblonga*	Sub-optimal (T_H)	S	-5 ^{o} C	Perennial deciduous tree; first harvest after 2 years; economic life 25 years
Turmeric	*Curcuma longa*	Not recom. (T_H)	S	Frost	Perennial rhizomatous herb; harvest after 270-300 days

FIELD CROPS					
Kikuyu grass	*Pennisetum clandestinum*	Sub-optimal (T_H)	S	-2° C	Perennial short sod grass
Lentil	*Lens cullinaris*	Optimal	S	0° C	Annual bushy herb; early cultivars 70-120 days; late cultivars 120-130 days
Lucerne	*Medicago sativa*	Optimal	S;W	-25° C	Perennial; growing season 100-365 days per year
COMMON NAME	**BOTANICAL NAME**	**CLIMATE SUITABILITY**	**GROWING SEASON**	**KILLING TEMPERATURE**	REMARKS
Maize	*Zea maize*	Sub-optimal (T_H)	S	0 C	
Potato	*Solanum tuberosum*	Optimal	S	-1 C	Annual tubercular herb; 90-160 days
FLOWER CROPS					
Chrysanthemum	*Chrysanthemuim carinatum*	Optimal	S;W;T		Annual
Gladiolus	*Gladiolus spp*	Sub-optimal			Annual bulb
Roses	*Rosa spp*	Optimal	S	Very low	Perennial deciduous shrub

Table 7.2: Soil salinity threshold values for different crops

COMMON NAME	THRESHOLD ELECTRICAL CONDUCTIVITY, EC_e ($mS\ m^{-1}$)	SLOPE (% CROP LOSS FOR EACH $mS\ m^{-1}$ INCREASE IN EC_e)	SENSITIVITY CLASS WITH RESPECT TO SALINITY
Camomile	L	Unknown	Sensitive to moderately sensitive
Common liquorice	M	Unknown	Tolerant
Coriander	L	Unknown	Sensitive to moderately sensitive
Corn mint	L	Unknown	Sensitive to moderately sensitive
Dandelion	L	Unknown	Sensitive to moderately sensitive
Digitalis	L	Unknown	Sensitive to moderately sensitive
Endive	L	Unknown	Sensitive to moderately sensitive
Fennel	L	Unknown	Sensitive to moderately sensitive
Garlic	L	Unknown	Sensitive to moderately sensitive
Ginger	L	Unknown	Sensitive to moderately sensitive
Linseed	170	0.12	Moderately sensitive
Parsley	M	Unknown	Moderately tolerant
Peppermint	M	Unknown	Moderately tolerant
Pyrethrum	Unknown	Unknown	Unknown
Rosemary	M	Unknown	Moderately tolerant
Safflower	M	Unknown	Moderately tolerant

COMMON NAME	THRESHOLD EC_e ($mS\ m^{-1}$)	SENSITIVITY CLASS WITH RESPECT TO SALINITY
VEGETABLE CROPS		
Asparagus	410	Tolerant
Beetroot	400	Moderately tolerant
Bean	100	Sensitive
Broad bean	160	Moderately sensitive
Broccoli	280	Moderately sensitive
Brussels sprouts	150-320	Moderately sensitive
Cabbage	180	Moderately sensitive
Carrot	100	Sensitive
Cauliflower	150-300	Moderately sensitive
Celery	180	Moderately sensitive
Chard	400-500	Moderately tolerant
Chicory	M	Moderately tolerant
Chinese cabbage	150-320	Moderately sensitive
Chives	L	Sensitive to moderately sensitive
Collard	130-320	Moderately sensitive
Cucumber	250	Moderately sensitive
Dill	L	Sensitive to moderately sensitive

COMMON NAME	THRESHOLD, EC_e ($mS\ m^{-1}$)	SENSITIVITY CLASS WITH RESPECT TO SALINITY
Horseradish	L	Sensitive to moderately sensitive
Kohlrabi	150-320	Moderately sensitive
Leek	L	Sensitive to moderately sensitive
Lettuce	130	Sensitive
Morag (African spinach)	M	Moderately tolerant
Onion	120	Sensitive
Pea	100-120	Sensitive
Pumpkin	150-300	Moderately sensitive
Radish	120	Moderately sensitive
Rhubarb	Unknown	Unknown
Salsify	L	Sensitive to moderately sensitive
Spinach	200	Moderately sensitive
Squash zucchini	470	Moderately tolerant
Strawberry	100	Sensitive
Tomato	250	Moderately sensitive
Apricot	160	Sensitive

COMMON NAME	THRESHOLD EC_e ($mS\ m^{-1}$)	SENSITIVITY CLASS WITH RESPECT TO SALINITY
Black currant	100-120	Sensitive
Black raspberry	150	Sensitive
Cranberry	L	Sensitive to moderately sensitive
Dewberry	150	Sensitive
European gooseberry	L	Sensitive to moderately sensitive
Grape	150	Moderately sensitive
Kiwi fruit	L	Sensitive to moderately sensitive
Mulberry	L	Sensitive to moderately sensitive
Peach	170	Sensitive
Pecan nut	L	Sensitive to moderately sensitive
Pistachio nut	M	Moderately tolerant
Plum	150	Sensitive
Quince	L	Sensitive to moderately sensitive
Turmeric	L	Sensitive to moderately sensitive
Kikuyu grass	M	Moderately tolerant
Lentil	L	Sensitive to moderately sensitive
Lucerne	200	Moderately sensitive

COMMON NAME	THRESHOLD ELECTRICAL CONDUCTIVITY, EC_e ($mS\ m^{-1}$)	SENSITIVITY CLASS WITH RESPECT TO SALINITY
Maize	170	Moderately sensitive
Potato	170	Moderately sensitive
Azalea	< 200	Sensitive
Carnation	200-300	Moderately sensitive
China Aster	< 200	Sensitive
Chrysanthemum	200-300	Moderately sensitive
Gardenia	< 200	Sensitive
Geranium	< 200	Sensitive
Gladiolus	< 200	Sensitive
Lily	< 200	Sensitive
Oleander	300-400	Moderately tolerant
Poinsettia	200-300	Moderately sensitive
Roses	200	Moderately sensitive

Table 7.3: Water quality guidelines (EC) for a theoretical 100% yield potential

Common Name	Sensitivity Class	Sandy soil	Clay soil
Vegetable Crops			
Asparagus	Tolerant	342 mS/m	186 mS/m
Beans	Sensitive	83 mS/m	45 mS/m
Beetroot	Moderately tolerant	333 mS/m	182 mS/m
Broccoli	Moderately sensitive	233 mS/m	127 ms/m
Brussels sprouts	Moderately sensitive	125 mS/m	68 mS/m
Cabbage	Moderately sensitive	150 mS/m	125 mS/m
Carrot	Sensitive	83 mS/m	45 mS/m
Cauliflower	Moderately sensitive	125 mS/m	68 mS/m
Celery	Moderately sensitive	150 mS/m	81 mS/m
Chard	Moderately tolerant	333 mS/m	182 mS/m
Lettuce	Sensitive	108 mS/m	59 mS/m
Morog (African spinach)	Moderately tolerant	333 mS/m*	182 mS/m*
Onion	Sensitive	100 mS/m	55 mS/m
Pea	Sensitive	83 mS/m	45 mS/m
Pumpkin	Moderately sensitive	158 mS/m	86 mS/m
Spinach	Moderately sensitive	167 mS/m	91 mS/m
Strawberry	Sensitive	83 mS/m	45 mS/m
Herbs, medical, spices	**and industrial**		
Garlic	Sensitive	100 mS/m*	55 mS/m*
Parsley	Moderately tolerant	333 mS/m*	182 mS/m*
Peppermint	Moderately tolerant	333 mS/m*	182 mS/m*
Perennial fruit, nut crop	**and berry**		
Apricot	Moderately sensitive	133 mS/m	73 mS/m
Black currant	Sensitive	83 mS/m*	45 mS/m*
Cranberry	Sensitive	83 mS/m*	45 mS/m*

Dewberry	Sensitive	83 mS/m*	45 mS/m*
Grape	Moderately sensitive	125 mS/m	68 mS/m
Common Name	**Sensitivity Class**	**Sandy soil**	**Clay soil**
Peach	Moderately sensitive	142 mS/m	77 mS/m
Plum	Moderately sensitive	125 mS/m	68 mS/m
Field crops			
Lucerne	Moderately sensitive	167 mS/m	91 mS/m
Maize	Moderately sensitive	150 mS/m	81 mS/m
Potato	Moderately sensitive	142 mS/m	77 mS/m
Flower crops			
Azalea	Sensitive	83 mS/m*	45 mS/m*
Carnation	Moderately sensitive	150 mS/m*	81 mS/m*
Chrysanthemum	Moderately sensitive	150 mS/m*	81 mS/m*
Gardenia	Sensitive	83 mS/m*	45 mS/m*
Geranium	Sensitive	83 mS/m*	45 mS/m*
Lily	Sensitive	83 mS/m*	45 mS/m*
Poinsettia	Moderately sensitive	150 mS/m*	81 mS/m*
Roses	Moderately sensitive	167 mS/m	91 mS/m

Unsure ratings are indicated by *

7.4.2 Influence of Different Water Qualities On Crop Production

Threshold values for the different crops have been based on studies with NaCl or NaCl/$CaCl_2$ mixtures. But it is also known that plants can grow at higher $CaSO_4$ concentration than NaCl concentrations (the osmotic effect for NaCl is about 2.5 to 3 times higher than the osmotic effect for $CaSO_4$). According to Maas (1986), plants grown in a gypsiferous environment will tolerate electrical conductivity values "approximately" 200 mS/m higher than those indicated in the tables. Therefore the partially treated water, which will be NaCl dominant, and the current gypsiferous water has approximately the same salinity threshold value. That is also the reason why salt sensitive plants such as carrots and lettuce have been successfully grown in the Blesbokspruit catchment for several years, using effluent mine water.

According to Table 7.3, a theoretical 100 % yield potential is possible for most crops, for the partially treated water with an electrical conductivity of 100 mS/m on the sandy soils with the exception of the most sensitive crops such as beans, carrots, peas, berries and certain flowers. On the clay soils, only the crops that are moderately tolerant to tolerant will have a theoretical 100 % yield potential for the partially treated water. For the fully treated water all crops can be grown, even on the clay soil.

According to Table 7.4, yield losses of 6.6 % for strawberries, 3.8 % for beans, 3.2 % for peas and black currant, and 2.8 % for carrots can be expected if the partially treated water of 100 mS/m is used on sandy soil. If the fully treated water is used, no crop losses will appear, even on the clay soil. If the partially treated water of 100 mS/m is used on the clay soil, losses as high as 39.6 % for strawberries and 22.8 % for beans can be expected. This illustrates the fact that only soils that are irrigable should be used when effluent water is used for irrigation.

Table 7.4: Sensitivity of crops to soil salinity induced by two different water qualities on a sandy and clay soil

Common Name	**Sandy soil**		**Clay soil**	
Vegetable Crops	**Water 100 mS/m**	**Water 40 mS/m**	**Water 100 mS/m**	**Water 40 mS/m**
Asparagus	No loss	No loss	No loss	No loss
Beans	3.8 %	No loss	22.8 %	No loss
Beetroot	No loss	No loss	No loss	No loss
Broccoli	No loss	No loss	No loss	No loss
Brussels sprouts	No loss	No loss	9.1 %	No loss
Cabbage	No loss	No loss	3.9 %	No loss
Carrot	2.8 %	No loss	16.8 %	No loss
Cauliflower	No loss	No loss	9.1 %	No loss
Celery	No loss	No loss	3.8 %	No loss
Chard	No loss	No loss	No loss	No loss
Lettuce	No loss	No loss	11.7 %	No loss
Morog(African spinach)	No loss	No loss	No loss	No loss
Onion	No loss	No loss	16.0 %	No loss
Pea	3.2 %	No loss	19.2 %	No loss
Pumpkin	No loss	No loss	9.1 %	No loss
Spinach	No loss	No loss	1.52 %	No loss
Strawberry	6.6 %	No loss	39.6 %	No loss
	Sandy soil		**Clay soil**	
Herbs, medical, spices	**Water 100 mS/m**	**Water 40 mS/m**	**Water 100 mS/m**	**Water 40 mS/m**
Garlic	No loss	No loss	(16 %)	No loss
Parsley	No loss	No loss	No loss	No loss
Peppermint	No loss	No loss	No loss	No loss
	Sandy soil		**Clay soil**	
Perennial fruit, nut crop	**Water 100 mS/m**	**Water 40 mS/m**	**Water 100 mS/m**	**Water 40 mS/m**
Apricot	No loss	No loss	14.4 %	No loss
Black currant	3.2 %	No loss	19.2 %	No loss
Cranberry	No loss	No loss	(15. %)	No loss
Dewberry	No loss	No loss	15.4 %	No loss
Grape	No loss	No loss	6.72 %	No loss
Peach	No loss	No loss	10.5 %	No loss
Plum	No loss	No loss	(14 %)	No loss
	Sandy soil		**Clay soil**	
Field crops	**Water 100 mS/m**	**Water 40 mS/m**	**Water 100 mS/m**	**Water 40 mS/m**
Lucerne	No loss	No loss	1.4 %	No loss
Maize	No loss	No loss	6 %	No loss
Potato	No loss	No loss	6 %	No loss
	Sandy soil		**Clay soil**	

Flower crops	Water 100 mS/m	Water 40 mS/m	Water 100 mS/m	Water 40 mS/m
Azalea	No loss	No loss	(2 %)	No loss
Carnation	No loss	No loss	(2 %)	No loss
Chrysanthemum	No loss	No loss	(No loss)	No loss
Gardenia	No loss	No loss	(2 %)	No loss
Geranium	No loss	No loss	(2 %)	No loss
Lily	No loss	No loss	(2 %)	No loss
Poinsettia	No loss	No loss	(No loss)	No loss
Roses	No loss	No loss	2.2 %	No loss

Unsure ratings are indicated by ( )

Table 7.5: SAR-values for untreated, partially treated (incomplete salts removal) and fully treated water (Data provided by Proxa)

	Untreated (me/l)	**Partially RO Treated** (me/l)	**Fully RO Treated** (me/l)	**BioSURE Treated** (me/l)
SAR	**2.41**	**8.29**	**5.85**	**2.91**
Na	10.43	10.43	3.04	4.74
Ca	21.10	3.00	0.50	3.5
Mg	16.28	0.17	0.04	1.79
Cl	5.19	5.19	< 2	2.37

7.4.3 Soil sodicity

The SAR is an index of the potential of a given irrigation water to induce sodic soil conditions. According to Table 7.5 the untreated water has on average a SAR of only 2.41, but by fully treating the water with RO the SAR goes up to 5.85 (142 % increase) and by partially treating it goes up to a SAR of 8.28 (244 % increase). For the BioSure treated water the SAR is slightly higher than the untreated water at 2.91 (17% increase).

Soils become sodic when the water soaking through them contains much sodium and lower amounts of calcium and magnesium. The higher the proportion of sodium in a water in relation to the proportion of calcium and magnesium, the higher the SAR ratio of that water, and the more damage it will cause a soil. Increasing SAR means that sodium increasingly replaces other ions on colloid surfaces. The soil then becomes increasingly sodic.

Most roots have some ability to stop sodium from being taken up into the plant. But when there is little calcium and magnesium in the water, the sodium soon overcomes this ability. It can damage root cells and it accumulates in leaf margins where it adds to any damage done by chloride.

According to DWAF (1996), soil sodicity is induced by irrigation with sodium-rich water. Negative effects associated with sodium-affected soils include:

- Reduced crop yield and quality as a result of sodium uptake through the roots of sodium-sensitive plants.
- Impaired soil physical conditions, as manifested by reduced soil permeability (infiltration rate and hydraulic conductivity) and an increased tendency for hardsetting.
- Reduced crop yield and quality

The most prominent impairment to soil physical condition by sodium under irrigation is reduced soil permeability, which may, in turn, result in the soil not being able to absorb sufficient water to supply the crop water requirement. A reduction in soil permeability can be the result of a reduction in either infiltration rate or hydraulic conductivity. Another impairment resulting from elevated Na levels is the physical deterioration of the topsoil. This is manifested by soil hardsetting, which manifests as difficult cultivation conditions and poor tilth (slippery when wet and hard clods when dry).

7.4 CONCLUSION

- Climatologically, forty-four crops are optimally and eighteen sub-optimally adapted to the study area
- With the exception of the salt-sensitive crops, BioSURE treated water, and the partially RO treated water of 100 mS/m, would be suitable for irrigation on irrigable soils. The partially treated RO water can, however, be problematic on clay soils with a poor internal drainage capacity. All the crops could be irrigated on all the soils with the fully treated water, which has an electrical conductivity of 40 mS/m.
- From a salinity/osmotic effect point of view, there is very little difference between the partially treated water (100 mS/m) which is NaCl dominant, and the untreated water (320 mS/m) which is $CaSO_4$ dominant, because the osmotic effect for NaCl is about 2.5 to 3 times higher than the osmotic effect for $CaSO_4$. According to the literature, plants grown in a gypsiferous environment will tolerate electrical conductivity values "approximately" 200 mS/m higher than those in a sodium environment.
- The replacement of gypsiferous water by the partially treated RO water would result in a SAR increase of 244 %. This would have serious consequences on the sustainability of the current irrigation in the area.
- The SAR increase for the BioSURE treated water was low at 17%.

8.CROP PRODUCTION POTENTIAL IN EASTERN EKURHULENI

Daan Louw
Optimal Agricultural Business Systems
Paarl

The main objective of the report is an assessment, with the best available knowledge, of the feasibility of the utilisation of treated mine water with irrigation crops in Eastern Ekurhuleni. The time and fund constraint on this project did not allow for an intensive data collection and verification process. The study focused only on existing crop data for the region.

Production costs of crop enterprises vary considerably, from farm to farm and season to season. The variations are based on the unique character of each operation and the uncertainty of factors beyond the control of the farm operator. The source of some of the differences can be found in several key input categories, such as: (1) machinery costs which can vary because of the differences in age, size, and usage of equipment; (2) irrigation costs which are subject to variations in rainfall, temperature, and irrigation systems; (3) fertilizer, seed, and chemical costs which will vary depending on quantities used and prices paid; and (4) labor costs which are dependent on prevailing wage rates, working conditions, and the efficiency of individual workers. Standardized values have been used in the estimation of production costs, assuming typical practices under average conditions on commercial farms. Thus, the budgets included in this study are intended to be used as a guide to estimate the feasibility of the production of irrigation crops to utilize semi-purified water.

Crop production costs include expenses for materials used in production such as fertilizers, chemicals, seeds or plants, and fuel; costs of land, labor, machinery and management; and irrigation and marketing costs where applicable. In addition, interest on operating capital was charged on variable costs in all cases. Since standardized values have been used in the development of the budgets, they are able to provide the type of information needed for management decisions and for comparing relative profits and cost structures between enterprises.

8.1 METHODOLOGY

The methodology followed in the study was as follows:

1) Identify crops that will be physically-biologically adapted for the region at different water qualities.
2) Market scan for these crops. Given the time limit it will only be possible to do an abridged market study. However, experience showed that it is in most cases fairly easy to establish whether there is market potential or not.
3) Estimate the direct production costs. These only include costs which are easy to allocate to a specific crop enterprise. All other costs are overhead costs (e.g. accounting, telephone, consultation, interest, depreciation) which cannot be calculated in this study since there is not enough information to establish exactly what this will be. For the purpose of this study it will be necessary to make a rough estimate of what these costs could be. The reader should,

however, be aware that it will only be possible to make more accurate estimates once specific projects have been identified.

4) Estimate gross margins with optimal water quality and at no cost. This analysis will be used as a base analysis to compare different water quality and cost scenarios.
5) Estimate gross margins for different water quality and cost scenarios.
6) Prioritise crops according to gross margin for the different scenarios.
7) Report on the findings.

8.2 CROP SELECTION

Nell (in Section 7 above) has identified crop categories which are adapted to the region, and taking into account different physical and biological factors and water qualities. A survey has thus been undertaken to establish market and income potential of the various crop categories considered.

Herbs, Spices, Medical And Industrial Crops

Camomile
Corn mint
Dandelion
Endive
Fennel
Garlic
Parsley
Peppermint
Pirethrum
Chives (already produced in the region)
Collard
Dill

Vegetables
Asparagus
Beetroot (already produced in the region)
Bean (Green and Dry) (already produced in the region)
Broad been
Broccoli (already produced in the region)
Brussels sprouts (already produced in the region)
Cabbage (already produced in the region)
Carrot (already produced in the region)
Cauliflower (already produced in the region)
Celery (already produced in the region)
Globe artichokes
Horseradish
Lettuce (already produced in the region)
Morog (already produced in the region)
Onion (already produced in the region)
Pea (already produced in the region)
Radish (already produced in the region)
Rhubarb

Salsify
Spinach (already produced in the region)
Turnips

Perennial Fruit, Berry and Nut Crops
Black raspberry
Cranberry
Peach
Plum
Strawberry

Field Crops
Kikuyu grass (already produced in the region)
Lentil
Lucerne (already produced in the region)
Maize (already produced in the region)
Potatoes (already produced in the region)
Wheat (already produced in the region)

Flower Crops
Carnation
Chrysanthemum
Gardenia
Gladiolus
Roses

Although Nell also identified flower production as an alternative he pointed out that flower production may not be a solution to get rid of the substantial volumes of mine water since, in general, their water demand is relatively low compared to other irrigation crops. Also, it will be necessary to produce flowers in a protective environment and with advanced irrigation systems to prevent direct contact between the irrigation water and leaves.

8.3 MARKET SURVEY OF SELECTED IRRIGATION CROPS

The reader should be aware that very little marketing data and/or information exists for many of the identified crops in South Africa. This is especially a problem with regard to some of the herbs and spices and for some of the vegetables which are only produced in small quantities in South Africa and are normally marketed in a closed exclusive marketing environment where information is not exchanged to “outsiders”. For the purpose of this report it was therefore decided to look at the market potential for five main groups of crops identified by Nell above. However, where it was possible to obtain information for individual crops within these groups the information will be discussed in more detail.

8.4 HERBS, SPICES, MEDICAL AND INDUSTRIAL CROPS

The term "herb crop" can refer to a number of different agricultural enterprises. Native plants known as "medicinal herbs" have been proposed as an alternative to commodity crops. Businesses can be based on culinary seasoning, fragrance, handicrafts, teas, landscaping, or other uses of herbs. This overview explores production and marketing considerations, especially for small growers and organic growers.

It is important to distinguish the conventional worldwide botanicals market (which provides plant materials widely used in the flavor, fragrance, and nutraceutical industries) from the alternative herb movement. Some promising alternatives are emerging-for both small and large-scale sustainable producers. However, access to conventional marketing channels (characterized by production contracts, selling on the spot market, and supplying manufacturers) is very difficult for most farmers and often unprofitable. Companies that manufacture mass-marketed nutriceuticals seek the cheapest raw materials possible, almost invariably sourced overseas. While marketing channels for sustainably produced herbs are still under development, usually they consist of some form of "relationship marketing."

Following is a description of the herbs identified which are physical biological adapted for the region:

Annuals
Chamomile (Matricaria recutita)
Dill
Garlic
Lemon mint
Parsley

Perennials
Chamomile (Anthemis nobilis)
Chives
Fennel
Horseradish
Mints
Pyrethrum

Garlic (Allium sativum): Medicinal garlic has multiple curative and preventative uses. Garlic has anti-fungal and anti-bacterial properties. Garlic has a reputation for lowering blood pressure and blood cholesterol levels. It's also known for improving the health of the cardio-vascular system

Horseradish is a perennial plant that originated in Russia or southern Europe. The plant (rhizomes and the root) is used in condiments and can be eaten as a vegetable. The primary use of horseradish is for the extraction of horseradish peroxidase. This is an enzyme that can be used for the treatment of the AIDS virus.

Parsley (*Petroselinum hortense*). A biennial plant growing up to 1 1/2 ft. Seeds should be soaked in water and then germinated at 70°F. Emergence will occur in about 25 days. This plant can be grown indoors. The leaves and stem are used as a garnish in salads and as a condiment. Popular in Italian dishes.

Chamomile, German (*Tripleurospermum maritimum*). An annual that grows up to 1 ft high. Germination takes place in 15 days at 65°F. Seeds require light for germination. Its flowers are used for tea. It is said to be medicinal. It is claimed to repel fleas, beetles, and other insects.

Camomile, English or Roman (*Chamaemelum nobile*). The flowers are used to make a tea. Often used as a tonic and as a skin lotion to keep insects away. This perennial is well adapted to partial sun and grows to 1 ft high. Seeds require 15 days at 65°F for germination.

Chives (*Allium schoenoprasium*). A popular window box herb. Adds flavor to soups, stews, pickles, pot roast, and baked potatoes. It is a perennial that grows to 1 ft in height and requires 20 days at 70°F for germination. It is said to repel aphids.

Dandelion (*Taraxacum officinale,* Weber, *T. Densleonis,* Desf; *Leontodon taraxacum*, Linn.), though its flowers are more conspicuous in the earlier months of the summer, it may be found in bloom, and consequently also prolifically dispersing its seeds, almost throughout the year. Parts used medicinally are the roots, fresh and dried, and the young tops. All parts of the plant contain a somewhat bitter, milky juice (latex), but the juice of the root being still more powerful is the part of the plant most used for medicinal purposes. It exercises a stimulating influence over the whole system, helping the liver and kidneys to do their work and keeping the bowels in a healthy condition, so that it offers great advantages to dyspeptics and does not cause wakefulness.

Dill (*Anethum graveolens*). A biennial plant, up to 2 ft in height. At 70°F seeds germinate in 15 days. It's leaves and seeds are used as a condiment. Leaves are commonly used in tuna and chicken salad. Seeds are used in bread, pickling, soup, salad dressing, meat, fish, and poultry.

Mint, curled (*Mentha spicata 'Crispata'*). Perennial, up to 2 ft high. Can be grown indoors or in partial shade. Seeds will germinate in 20 days at 70°F. Leaves are used for sauces and as a condiment. Mint will spread unless it is confined.

Peppermint (*Mentha piperita*). A tender perennial growing up to 3 ft tall if protected. Seeds require light and 15 days at 70°F for germination. Its leaves are used for tea and as a condiment. Said to be medicinal.

Pyrethrum remains the most unique and widely used bio-pesticide in existence. Originating from the beautiful white chrysanthemum flower, it has an extraordinary speed of action against a very wide range of insect pests, yet it is <u>not</u> persistent in our environment, as it quickly disintegrates leaving no toxic residues. Pyrethrum wholly satisfies the requirements of the organic crop and animal producer. In addition, it has always had a very special place in the battle to control mosquitoes, which carry lethal diseases and played a vital part in the fight against malaria during World War 2.

Fennel (*Foeniculum vulgare*). A biennial or perennial plant that will grow as an annual if not protected. It can reach 3–5 ft in height. Its seeds and leaves are used as garnishes and to produce flavoring oils. Like celery, it is cooked as a vegetable. Good in salads and with seafood.

Spearmint (*Mentha spicata*). A perennial plant, up to 2 ft high. Can be grown indoors or in partial shade. Seeds require 15 days at 70°F for germination. The leaves are used as a condiment and are popular in julep drinks.

8.4.1 Fresh herbs

An important consideration in marketing fresh herbs is their seasonal production, their limited shelf life and the limited distances they can be transported to markets because of spoilage problems. Fresh herbs can be sold by growers directly to consumers through farmers markets or farm gate sales. Live plants are sold at farmer's markets, garden centres and landscape stores. Producers may be able to develop markets for live plants with hotels and restaurants. A key requirement of direct to consumer sales is the inclusion of recipes and instructions to assist consumers to use herbs in meal preparations. Consumers may be willing to pay a premium price for fresh herbs that can be certified as organically grown. Fresh herbs can also be sold to restaurants and grocery stores. The key to success in this market is being able to provide a consistent supply of a high quality product. An obstacle for producers is not being able to supply product on a year round basis. Selling to this market may require a location close to major markets in order to ensure minimal spoilage.

The markets for fresh herbs may require some level of packaging such as bunching, cartons, cases or zipper lock bags. It is also important to be able to monitor the condition of the product.

Fresh herbs can also be marketed directly to brokers, wholesalers and distributors, but be aware that over supply can have a drastic effect on prices. The consumption of fresh herbs has increased considerably over time primarily due to the consumer's increased demand for "fresh" food products together with an increased supply of herbs being made available to consumers. The high expenses associated with accessing fresh herbs from certain regions during the winter months might be an opportunity for growers in other regions.

However the seasonal limits of herb production may restrict the growth of various markets since markets relying on a constant supply may not be able to stock fresh herbs year round. Small scale production of fresh herbs targeted at farmer's markets and specialty retail outlets may have the most potential for new entrants. However, these markets will be limited by the seasonal nature of herb production. Herbs are also sold on the national fresh produce markets in South Africa. Figure 8.1-8.5 shows the volume traded and the average monthly price for selected herbs on South African fresh produce markets for the 2001/2002 season. It is clear that the price of endives fluctuates between R2 000 and R3 000.

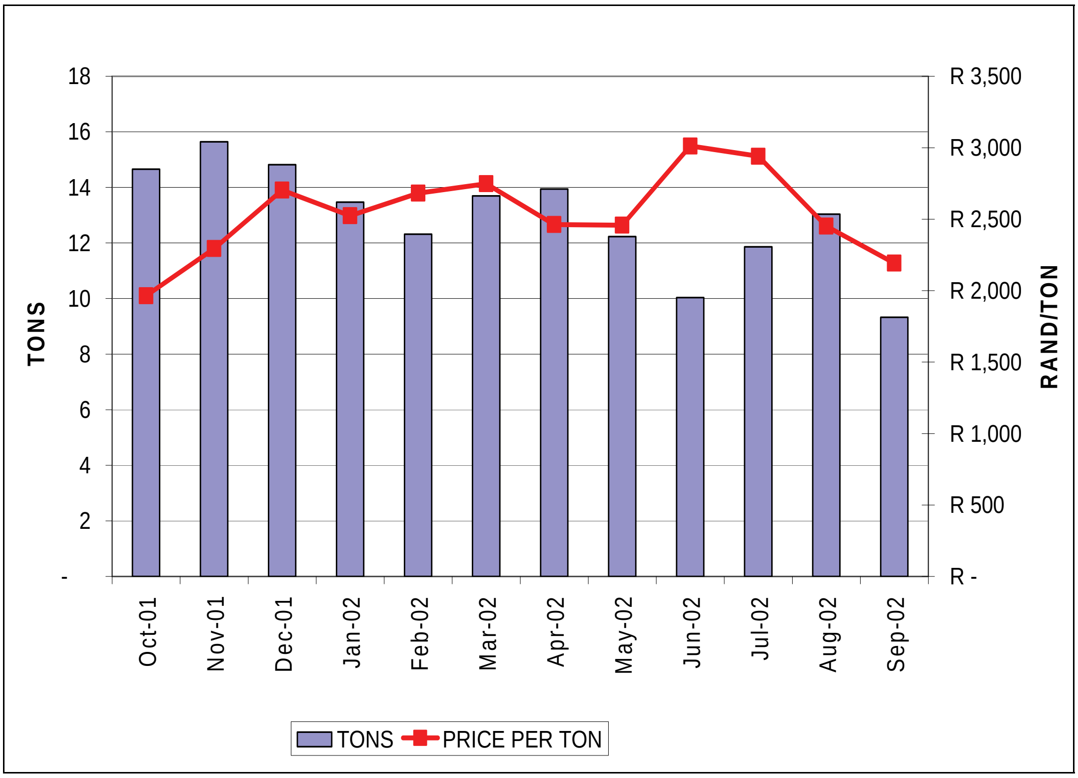


Figure 8.1: Endive price and volumes at fresh produce markets in South Africa
Source: NDA

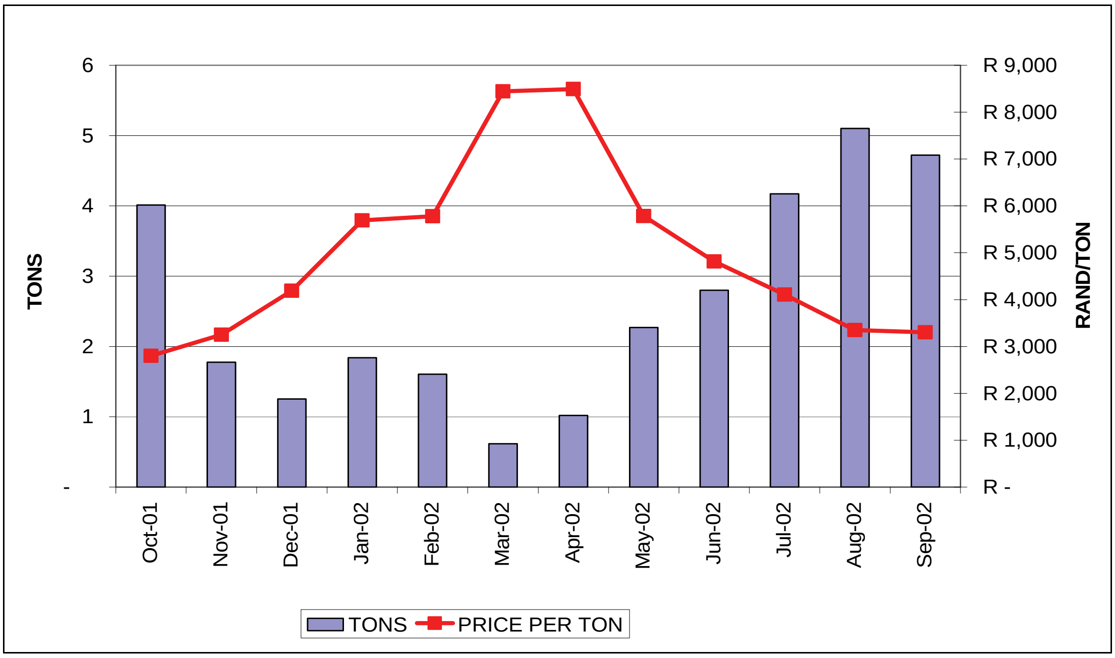


Figure 8.2: Fennel price and volumes at fresh produce markets in South Africa
Source: NDA

From figure 8.2 and 8.3 it is clear that the price of fennel and garlic fluctuates between R3 000-R9 000 and R7 000 to R15 000 respectively.

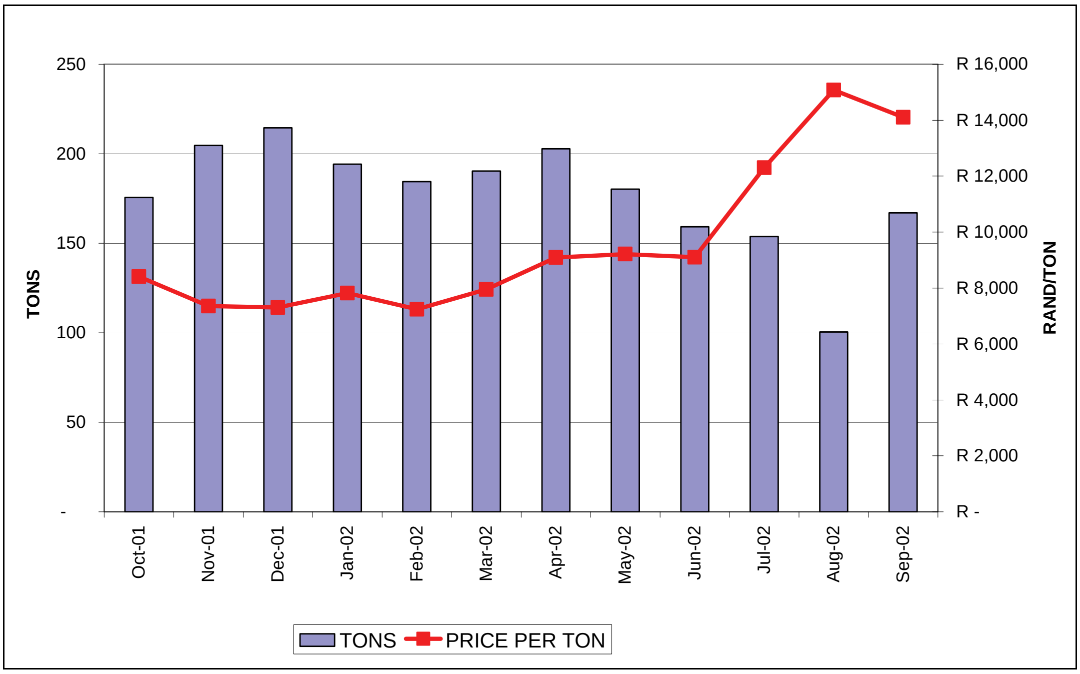


Figure 8.3: Garlic price and volumes at fresh produce markets in South Africa
Source: NDA

Figure 8.4 shows that the price of parsley fluctuates between R3 500 and R5 200 and reaches a peak during April.

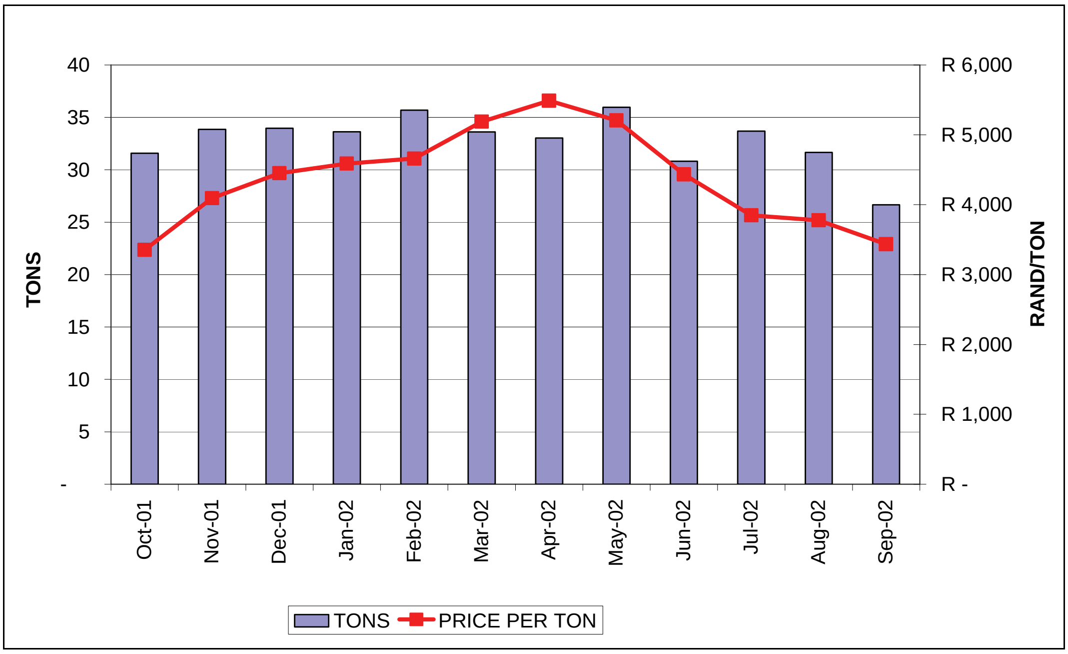


Figure 8.4: Parsley price and volumes at fresh produce markets in South Africa
Source: NDA

The reader should be aware that although prices are relatively high and compares good to other horticultural crops, the volumes traded are relatively small. Also, a small increase in production could easily result in a surplus on these markets. The national fresh produce markets only represent a part of the total fresh herb market in South Africa. Many of the fresh herbs are traded directly to retailers.

8.4.2 Medicinal herbs

Herbs are the leaves, roots and flowers of plants grown and processed for culinary, cosmetic, industrial, medicinal, decorative, flavoring and fragrance purposes. Medicinal herbs are grown to produce plant material containing ingredients that are believed to provide medical and health benefits. Among consumers there's a growing interest in alternative health products and resurgence in the use of medicinal herbs to improve health or alleviate the symptoms of a wide range of ailments.

A number of factors may be contributing to the increased consumer demand for medicinal herbs. These include:

- a growing public willingness to take responsibility for their own health
- dissatisfaction with health care costs
- increased focus on health and fitness
- increased acceptance that food has therapeutic value
- increased awareness of the importance of the preventative approach to medicine
- greater emphasis on more natural lifestyles

Most medicinal herbs are sold as dried or powdered products that are processed into tablet or capsule form. Other value-added forms include teas, tinctures, creams, oils and liquids. The most popular medicinal herb products are those that address the same symptoms as the top-selling over the counter drugs.

Medicinal herbs are most often sold as health food supplements which include nutraceuticals (a blend of a food and a medicinal herb), and phytomedicines (herbal supplements with standardized levels of biological materials). Medicinal herbs grow in the wild and under field cultivation. They are also being investigated as greenhouse crops. Medicinal herbs that are harvested where they are found growing naturally (wild crafting) are becoming scarce. As wild crafted herbs become scarce, cultivation may become more feasible. Under cultivation the quality and yield of medicinal plants can be improved, but the cost of growing cultivated medicinal herbs may be too high to compete with imported products, alternative herbs or synthetic drugs.

The world production and processing of medicinal herbs is concentrated in Europe (France, Germany and Hungary), China, India and Korea. South African production of medicinal herbs is small compared to world production.

However, it is generally accepted that growers of medicinal herbs in developed countries are challenged by developing countries that have lower labor costs, even though quality tends to vary and hygiene standards tend to be lower. Commercial growers can stay competitive by minimizing production costs, achieving a high, consistent quality (proven by lab tests) and developing a reputation within the industry.

In addition to production and processing activities, medicinal herb growers need to spend a significant amount of time on marketing. The production and marketing of medicinal herbs requires studying the markets for herbs, identifying target markets, determining how to market products in that market, researching the production requirements of each plant species grown and developing processing procedures required to meet customer needs in the target markets.

There are numerous medicinal herbs produced for many different markets. Each market has its own unique consumer requirements, as well as marketing and distribution channels. In most cases, meeting buyer needs and accessing the market can only be learned through experience. Increased interest in the production and marketing of medicinal herbs is due to the growing demand for medicinal herb products. Estimates of market growth range from two per cent to 10 per cent per year.

Potential growers must carefully assess:

- whether there's demand for a particular herb crop
- whether there's a market for the crop
- whether they can access the market
- whether they can grow the crop
- whether the proposed operation is viable.

The medicinal herb industry and the business potential for medicinal herb production is uncertain due to:

- an uncertain market size for medicinal herb products
- a lack of acceptance of medicinal herbs by the scientific and medical communities
- many low cost producers who dominate world production
- market information that is difficult to access
- a lack of quality control procedures
- a lack of information on the medicinal qualities of different herbs
- a lack of agronomic information on the various herbs
- changing rules governing medicinals.

New entrants must be prepared to deal with a shortage of published production information and few established markets. Individual producers who enter into the production and marketing of medicinal herbs should consider the following:

- learn about the market before getting involved with a crop
- understand what level of production and processing the market requires
- determine whether certified organic growing and processing are needed to gain access to markets
- expect to spend more time marketing these crops than producing them
- certified organic production may be the only way to gain access to certain markets and organic growers must be prepared to provide detailed documentation on all aspects of their operation
- start small

- investigate the potential to partner or co-operate with fellow growers in processing and marketing activities

The most popular herbal formulations tend to be laxatives, weight-loss remedies, immune system enhancers, sexual performance aids, anti-aging remedies and products to relieve anxiety and stress.

Unprocessed herbs, like many raw commodities, may only attract a modest price in the market place. Processing, however simple, adds value to herb crops.

Pharmaceutical companies and medicinal/supplement companies are the main players in the market for medicinal herbs. Pharmaceutical companies sell herb products for their medicinal value. This market tends to be dominated by large drug companies that acquire herbs in the exact form from suppliers. Often these companies require organic or chemical residue-free products. The drug companies are reluctant to develop products using natural plant material, particularly when a substitute synthetic product can be developed. This is primarily because these firms aren't able to patent plant materials and therefore not be able to recover the cost to bring a new drug to market.

The supplement industry is made up of:

- firms that specialize in the manufacturing, marketing and distribution of supplements
- drug companies that market supplements in the mass market channels, along with their pharmaceutical products
- bulk nutrient suppliers that purchase herbs and either dry or powder them for sale to firms, that produce tablets or capsules

Supplement manufacturers provide the majority of the herbal supplement products to retail markets. These manufactures tend to produce tablets or capsules from dried powdered herbs that they generally buy from bulk nutrient suppliers. About 80 per cent of medicinal herbs are sold in tablet form.

Bulk nutrient suppliers purchase dried bulk or pre-processed herbs for processing into the final market form. Buyers specialize in different products. Buyers generally make their selections based on color, aroma, flavor, texture, levels of medicinal properties (based on lab tests) and processing requirements. Growers are required to submit samples to buyers and may also be required to submit laboratory tests. Buyers tend to buy from as few sources as possible in order to maintain a consistent quality and have a reliable supply. New growers attempting to access this market will need to establish a reputation of consistent quality and reliable supply. Growers should also investigate co-operative marketing arrangements as means of accessing markets.

Growers must be prepared to investigate available prices and how the quoted prices vary according to the form (dried material, pre-processed), quality and quantity of the raw material. Different buyers have different scales of operation. Some buyers may only deal in container loads of product while others deal in quantities of 50 to 1 000 kilograms. The quantity requirements will affect access to a particular market, as well as the price per unit offered.

For many dried herbs, South African producers may be required to compete with foreign producers who produce large quantities at a lower cost of production primarily due to lower labor costs. South African producers should investigate producing herbs that have limited foreign competition.

8.4.3 Herbs for essential oils

Essential oils derived from plants are utilized extensively in the flavor and fragrance industry. In general, food-grade essential oils are preferred over vegetative matter as flavoring agents in food products to avoid development of molds and off-flavors. In addition to commercially prepared foods, over-the-counter medicines and many personal care products contain essential oils as flavoring agents. Essential oils produced on-farm by simple methods may be used in recipes for body care and household products. Aromatherapy, an alternative medical specialty, is the newest industry utilizing essential oils.

The major U.S. essential oil crop has historically been mint, produced in the Pacific Northwest under state marketing orders and in parts of the Upper Midwest, especially Indiana. Crude distillation begins in the field, but access to a processing plant is necessary. Although it is possible to distill essential oils at home by using a pressure cooker, only a few drops at a time are produced. Commercial production requires very large quantities of biomass, stringent quality control procedures, and laboratory testing facilities. Mint production in the USA declined by half in 1999 due to worldwide overproduction. The essential oils industry in this region is now actively seeking alternative crops.

8.4.4 International trade in herbs

It is very difficult to find reliable information of the international herb market. However Atkinson (2003) gives an indication of the extent of the industry in Europe.

Herbs and spices are extensively used in cooking in Europe. Owing to the absence of clear distinctions in the statistical data between fresh culinary herbs and vegetables on the one hand, and between herbs (excepting thyme and bay leaves) and other plants used in pharmacy, perfumery or as insecticides and fungicides on the other, an evaluation of market sizes can be made only on the basis of the estimates of the trade.

Domestic production in Europe consists mainly of parsley, sage, mint, thyme, dill, savory and tarragon. This production covers demand for fresh herbs and part of the requirement for dried herbs. Current imports of dried herbs into the four major European import markets are estimated at an average of 12 595 tons annually, of which 37.4% (4 705 tons) are supplied to France, 30.1% (3 785 tons) to Germany, 20.3% (2 555 tons) to the United Kingdom and 12.3% (1 550 tons) to the Netherlands.

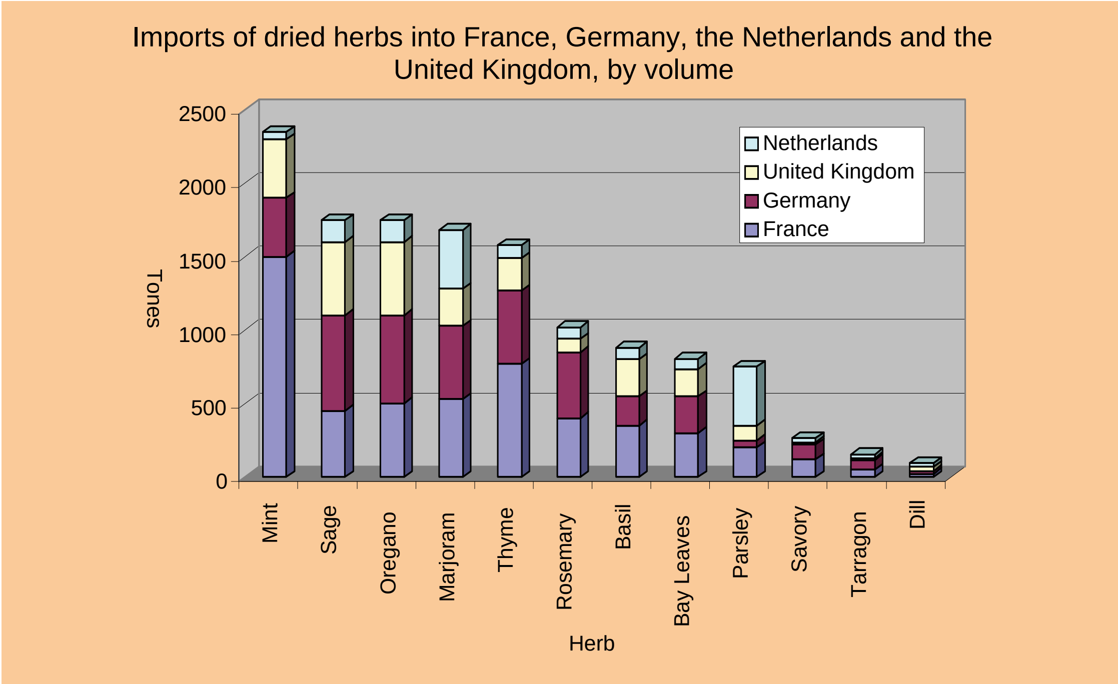


Figure 8.5: EU herb market

Intra-EU trade is also well developed and much larger tonnages of dried herbs are trans shipped through Hamburg and Rotterdam. Over three quarters (77%) of imports into the four markets consist of the following six herbs: sage, oregano, marjoram, mint, thyme and rosemary. Parsley is the most used herb, but the largest part of the demand is covered by domestic growers.

A lack of statistical data makes it impossible to forecast the evolution of demand. According to trade estimates, the market has an average annual growth rate of 1 to 2% in terms of tonnages. Although volumes will continue to rise, factors such as packaging in bulk or in larger quantities will dilute the effect on market growth in value terms. Growth rates differ for the various types of herbs and with the market sector in which the herbs are most used. Growth is expected to be much faster in the industrial food and institutional catering sectors, and more or **less** stagnant in the retail sector. Demand for marjoram, oregano, sage, thyme and bay leaves **are** therefore likely to grow faster than demand for the other herbs.

Several factors augur well for growth in Europe of consumption and imports of dried herbs.

- Rising incomes sustain the growth of demand.
- Immigration and travel increase the interest of the population in foreign cooking.
- Television and radio advertising and increased leisure time have a profound effect on the growth of demand for herbs and products required for ethnic or exotic cooking. Chinese, Creole, French, Greek, Indian, Indonesian, Italian, Mexican, Middle Eastern, Thai and Vietnamese cooking are in fashion and specific herb-and-spice mixtures are in demand for these types of food.

- Herbs are increasingly used in industrial food manufacture as natural preservatives and anti-oxidants; oregano and rosemary, for example, are extensively used as anti-oxidants in sausages and other meat products.
- The growing trend in Europe towards foods low in sugar and salt have led to the search for alternative ways of making them more palatable and to the development of herb mixes and spiced herb preparations.
- The boom in fast foods and microwave cooking has increased the use of more aromatic herbs in order to improve palatability.
- The move away from artificial flavourings and colourings in food has benefited the herb market; herbs are natural products which are marketed as "free from artificial colouring and/or preservatives".
- Ethnic and culinary herb display units are increasingly common in supermarkets and food stores, including those of the multiple grocers.

Imports into the three markets considered are handled by a handful of importers/dealers/brokers. The largest part of the trade takes place directly between the exporters and the large grinders/processors which in turn supply the retail, industrial and catering sectors. Tariffs do not present a real obstacle to trade. However, the stringent quality requirements, phytosanitary control regulations and especially the closed distribution network for retail packs in the European markets are particularly difficult to surmount. The market for dried herbs is not overly price-sensitive, but it places great importance on quality and on freedom from microbiological infestation. As no common quality standards exist in EU member countries, exporters have to comply with the quality standards and requirements established by individual importers, grinders and processors.

All the large importers in the three countries covered by this report tend to have close relationships with their traditional suppliers in Egypt, Hungary, Morocco, Spain and Turkey, for example, in order to secure supplies of consistent quality. If they wished to, they could encourage production in other countries by making direct investments and providing technical services in herb cultivation and processing.

Potential exporters should contact established importers or brokers in order to have their samples evaluated and to obtain advice on possibilities for penetrating a given market and market sector. The current market for dried herbs is not short of supplies and, all things considered, exporters seeking entry will have to compete with traditional suppliers. The only way to penetrate the market is to offer dried herbs of consistently high quality, be they in the crude or crushed form. Clean products of assured quality, good appearance and, if possible, with properties distinguishing them from their competitors (flavour, colour, content of essential oil) can secure a firm place in the European markets and in fact be sold at a premium over products from other origins.

Herb-consuming countries in Europe are quality conscious. Their quality requirements will become more stringent, particularly with respect to cleanliness and the use of herbicides and pesticides. As the major European users prefer to purchase herbs in the un-ground form, a producer will be unlikely to market herbs that have been processed beyond the initial drying stage unless he can ensure excellent and consistent quality.

Prices are generally rising as a result of both increased supply costs (production, processing and freight) and increased demand. However, as for most agricultural products, herb prices tend to fluctuate widely. The degree of fluctuation varies from herb to herb, quality being an important influencing factor. The specification determining the price of most herbs is the percentage of volatile oil, which gives the flavour strength: the higher the volatile oil content, the higher the price. It is essential to note that a higher priced herb might in fact be cheaper to the end-user, because it will go further in flavouring the finished product. Prices are also influenced by the content of extraneous matter: a contaminated herb, or one containing too large a proportion of stems will command a lower price. It is, however, worth mentioning that further cleaning may sometimes not raise a producer's net receipts, as the extra cleaning costs may be higher than the resulting additional revenue.

In general, industrial users tend to pay a lower unit price for most herbs, because the products they use are usually of a lower quality in terms of visual appearance. Price fluctuations are caused mainly by the supply situation: good harvests generally depress prices, while poor crops have the opposite effect. The harvest is dependent on weather conditions (rainfall and the duration of sunshine in particular), pests and diseases, as well as the implications of government policies. The level of producers' prices in turn has a direct influence on planting and collecting decisions. Low prices over a long period lead to substitute planting of more profitable crops or to an unwillingness to collect herbs from the wild. These in turn result in shortfalls in supply, subsequent price increases and consequent intensification of price fluctuations. The size of these fluctuations varies from herb to herb and is affected by supply and demand and the ease with which a herb of satisfactory quality can be produced.

Unlike mint, parsley, sage and thyme, few herbs are in sufficient demand to encourage their widespread commercial cultivation. The cultivation of most herbs can be expanded fairly quickly; therefore, even if supplies in the short term are relatively inelastic (generally one harvest per year), they are much more elastic over the long term. It is unusual for prices to remain high for several successive seasons. Another reason for the fairly inelastic demand over the short term is the unwillingness of processors and end-users -industrial food manufacturers in particular – to make sudden alterations to their formulations and supply origins. In the long term, however, the availability of alternative sources of supply or of close flavouring substitutes may result in a fairly elastic demand, especially for some individual herbs. Overall, the level of stocks does not appear to have a great stabilizing influence on prices. When prices are low and expected to rise, buyers may purchase much more than their normal requirements (usually from one harvest to the next, i.e. over a period of one year), and vice versa. Large importers and dealers maintain stocks in order to minimize the effect of price fluctuations and also to be able to satisfy short-term purchase requirements, However, most other users of herbs do not like to hold large stocks, partly because of quality deterioration problems, and partly because it is expensive to stock products of comparatively low value and high bulk.

Herb prices also depend on shipping costs and port and handling charges. Freight charges, calculated on the basis of cubic volume, account for a large part of the total price of herbs because of the ratio of their bulk (which is high) to their value (which is comparatively low). Traders' profit margins likewise contribute to the variation in herb prices. According to trade estimates, agents, brokers, dealers and importers charge prices that are generally 1.5 to 2 times higher than the exporters' FOB prices. Grinders/processors charge end-users, i.e. retail outlets, food caterers and industrial users, 3 to 10 times the exporters' FOB prices (see figure 8.6).

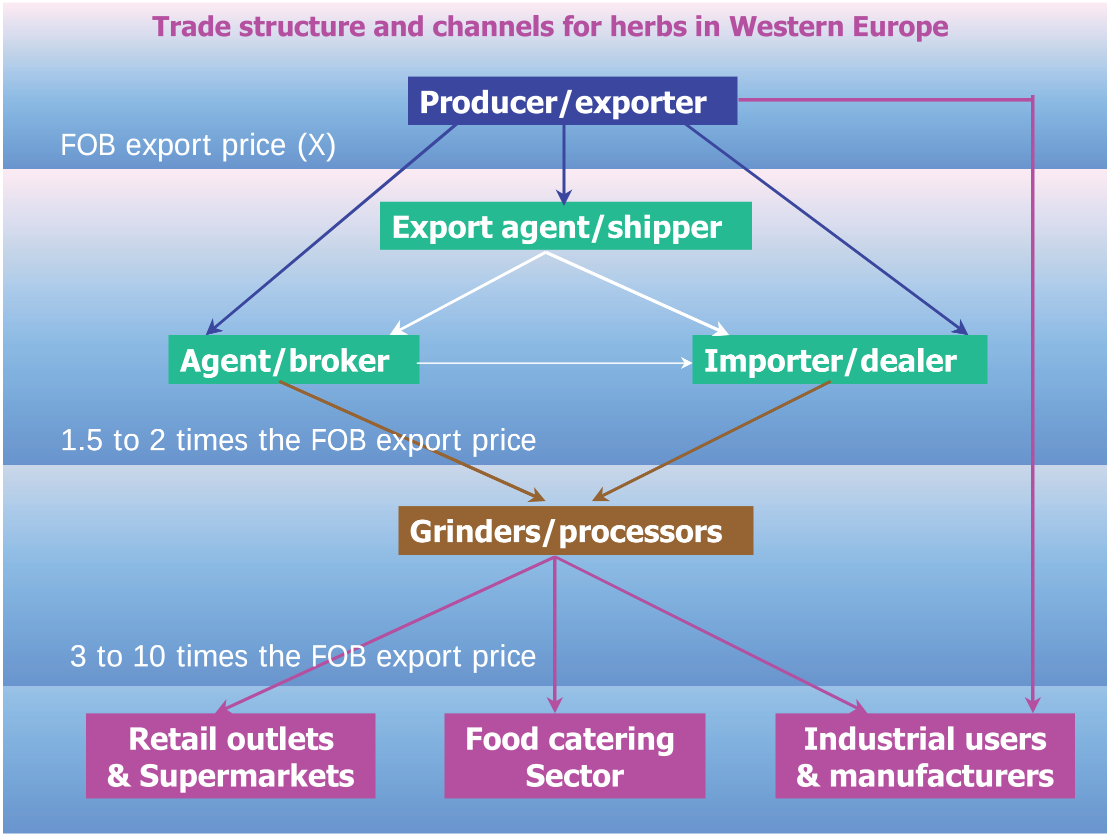


Figure 8.6: Trade structure for Herb trade in Western Europe

8.4.5 Production basics

Growers of herbs need to achieve a balance between producing the herbs that meet the demands of their target market and achieving efficient production, harvesting, storage and processing performance. When investigating the agronomic potential of different herb crops, growers must be prepared to research the different production, harvesting and drying practices that are required by each herb crop. In particular, producers must identify production limitations such as over-wintering, heat and moisture requirements, as well as the length of growing season for each crop being considered. Since many medicinal herb crops haven't been grown under cultivation on the East Rand, agronomic needs and production practices may not be available.

The critical production issues for herb and spice crops are crop selection, site selection, adaptability, seedbed preparation, seeding, fertilization, weed control, harvesting, storage and processing. Herbs can be classified as annuals, perennials or biennials. Producers should be familiar with the winter hardiness and adaptability of the different herb varieties. Perennials and biennials need to withstand harsh winter conditions and may require management practices such as fall mulching. Organic production of medicinal herbs will increase the acceptance of herbs by buyers and may bring higher prices. For many medicinal herbs, certified organic production may be the only way to gain access to a market. Organic herbs are generally valued at significantly higher prices that those for non-organic herbs.

When selecting a growing site, it's important to avoid areas where chemical residues may be present, where hard to control weeds are established and where spray drift may occur. Organic production (certified) has specific requirements with respect to weed control and chemical use. Certified organic production requires a three-year entry period in which a cover crop such as barley is grown and plowed down as green manure. Growers need to determine how different herb crops respond to sunlight. This is because sunlight may influence the production of ingredient(s) that provide the health benefit. Growers also need to determine how tolerant the various herb crops they select are to soil moisture. Many herbs require well-drained soils since their roots can weaken and die in excessively moist (and cool) soils. Most herbs have small seeds and require a firm seedbed to ensure soil contact and to increase germination. Seeding depth ranges from (0.3-1.19 cm), depending on soil moisture and seed size. Since few herbicides are available for herbs and herbs are often grown for organic markets, weed control may rely on manual and mechanical cultivation. Growers need to carefully consider the time/labor commitment in growing medicinal herbs. Irrigation may benefit herb crops, depending on the crop and the growing conditions. In particular, irrigation may allow growers to push their crops for earlier harvest and in some cases achieve two crops per year.

Harvesting requirements are determined by the market requirements for the form of the herb crops. For markets requiring dried bulk material, the herb crop requires drying and some form of bagging or baling. Drying must take place indoors, out of the sunlight. Material dried to 15 per cent moisture can be stored for six to 12 months. Protection from rodents and insects is an important consideration when storing dried herb material.

Growers can also add value to their medicinal herb crops by providing assurance of the potency of their herbs by obtaining laboratory analysis of specific marker ingredients. Further processing may be required to meet the needs of buyers. Growers must know the parts of the plants to be harvested, the requirements of their customers and the basic processing steps to be performed for each crop or market. The focus of production management is to achieve the precise product required by the market at an acceptable cost of production. The manager must achieve good performance in the areas of production, harvesting and processing.

8.4.6 Conclusion

Medicinal herb production and marketing in the East Rand could be a highly uncertain undertaking. New entrants must be prepared to carefully assess the profitability and cash flow implications of their proposed operation. Cost information for herb production is difficult to obtain. New growers must be prepared to research and carefully estimate prices, costs and operating requirements for their proposed operation. The production costs for individual herb enterprises may vary due to factors such as location, crops (annual or perennial), size, machinery, labor use and marketing activities. Detailed budgets are required to assess the profitability and cash flow implications of a proposed medicinal herb enterprise. The budget information provided in a following section are only estimates and are included to provide growers with a framework that identifies the type of information required and the type of analysis they should undertake. Growers must do their own budgeting before planting a crop.

The key determinants of the viability of a medicinal herb enterprise are capital investment, production parameters, operating costs and prices received for product.

8.5 VEGETABLES

The objective with this section is not to give a market overview of all of the individual vegetable crops which were identified for the purpose of this report. A more general discussion follows. However, where it was possible to obtain market information for individual crops from the national fresh produce markets, it is included to give the reader an indication of price and volume trends.

Marketing starts at the farm. Although growers may choose to focus their energy on crop production, when it comes to profitability, marketing the crop is equally important. Throughout the entire season – from seed to sale – many factors need to be considered to most efficiently, and most effectively, market your product. Marketing considerations occur prior to planting, during crop production, at harvest, in post harvest handling, package design, and finally, in sales.

Before a vegetable crop is even planted, the intended market should be determined. For example, a produce stand requires successive plantings of many crops, whereas wholesale production is best met with larger, but fewer, plantings.

The laws of supply and demand are ubiquitous in the fresh produce industry. Producers of a bumper crop are often faced with depressed prices, and prices are higher when the supply is low. So, when developing a marketing plan, it should be considered to extend crop seasons whenever economical. If it is possible produce a vegetable in a market slot earlier or later than the bulk production, higher prices may more than compensate for additional maintenance costs.

It is worthwhile to explore specialty-crop production – especially on small areas of production – but it is important to locate buyers for specialty crops before planting. Find out what buyers expect in terms of crop size, packaging, and handling. It could be possible to assist buyers to move to new crops if producers can supply promotional information such as proper storage conditions, nutritional content, or recipes and product uses.

As a vegetable grower, it is necessary to continually update management practices. Incorporating new techniques to increase yield or improve product quality invariably boosts the ability to market the product. Producers are well aware of the advantages of new crop varieties with improved characteristics, or the changing availability and effectiveness of pesticides. But other techniques to improve yield or quality may include midseason uniformity tests of drip irrigation systems to prevent uneven crop growth, or adjustments in fertilizer applications for best crop quality. Excess nitrogen in pepper, for example, has been shown to increase the likelihood of bruising injury after harvest; thus reducing product quality. Reduction in quality can cost growers significant losses in the marketplace.

In most perishable crops, peak quality occurs at the time of harvest. Crop quality cannot be improved after harvest, but the loss of quality can be slowed. It is important for vegetable farmers to know what crops need to maintain quality and what conditions cause injury. They should obtain basic post harvest information on temperature, humidity, chlorination, waxing, and ethylene interactions. It is also necessary to know with how much shelf-life is reduced if no pre-cooling is done.

It is of paramount importance that packaging be done in such a way as to preserve quality and promote the product. Standard packaging for a commodity should be used whenever appropriate. Investigate packaging options before changing systems. Package design should always appeal to consumers. Private brand names on produce are one way to promote products. Branding can be especially effective if combined with strict internal quality control. A regional identity permits several growers to share the costs of packaging and promotion. Logos to promote regional products have proven successful for some product, as for example, Ceres Potatoes or Ceres Onions. It is also important to note that buyers seek uniformity, so growers who share a label should also use a similar quality-assurance program.

Busy lifestyles lead consumers to seek ready-to-eat convenience foods. Pre-washed, mixed, and meal-sized containers are gaining in popularity. Value-added processing converts a commodity into a product, which may greatly expand market opportunities. Growers should ask themselves, why should a consumer buy our product? It is important to advertise aspects of the farm that would appeal to the general public. Let consumers know if the farm is for example a black empowerment operation or if practices are used that protect the environment.

Possibilities for marketing produce from the farm, based on greatest opportunity for returns, include the following:

- Retailing from a roadside market.
- Community farmer’s market.
- Combination pick-your-own roadside market.
- Pick-your-own operation.
- Selling to large area farm markets, local grocery stores or wholesalers.

Where you are going to sell your crop is an important question to answer. It is difficult to determine how well a crop may sell in any given year or what other crops may have potential.

There is no single more important factor than quality that will influence your ability to charge a fair price. People will pay a fair price for good produce. Monitoring prices of other growers or stores will indicate if you are too far “off base.” The price mechanism at the national fresh produce markets generally dictates vegetable prices.

Table 8.1 shows the average monthly price for selected vegetables on the national fresh produce markets. It is clear that some of these vegetables reach price levels of more than R10 000 per ton.

Table 8.1: Price information for selected vegetables (Rand/ton)

MONTH	Oct-01	Nov-01	Dec-01	Jan-02	Feb-02	Mar-02	Apr-02	May-02	Jun-02	Jul-02	Aug-02	Sep-02	Average
Asparagus	5704	8077	7593	12311	11567	11828	16540	26150	0	20000	28756	9876	13200
Beetroot	992	839	1153	1732	1791	1931	1412	1045	958	1088	1250	874	1255
Green beans	3421	2370	2035	2678	3200	2292	1834	2256	3357	3815	3667	2291	2768
Broad been	1302	1196	2730	3353	3900	4428	1551	2266	2406	2332	2117	1602	2432
Broccoli	3400	3558	3437	3930	4201	4000	3935	2759	2941	2864	2260	4612	3491
Brussels	5064	3481	5204	10264	7688	3586	2829	2799	4240	4553	6091	6418	5185
Cabbage	629	466	424	466	534	680	744	650	719	800	758	437	609
Carrot	1137	1011	1117	1280	1258	1870	2157	1428	1000	920	1240	1202	1302
Cauliflower	1160	1059	1084	1220	1387	1729	1433	1172	939	1002	864	1065	1176
Celery	4430	6375	4832	7139	9332	12146	8904	7968	7384	7552	5190	4792	7170
Clobe artichokes	3667	3166	3851	2933						14872	19200	8297	7998
Horseradish	13625	11250		46140	15101			23750			16732	21100	21100
Lettuce	1059	1248	1946	1808	1461	1362	1251	1158	1228	1196	1300	1303	1360
Onion	1427	1498	1564	1483	1477	1427	1726	1971	2295	2340	2350	2198	1813
Peas	3853	5944	9553	7111	8080	4868	6225	6749	6113	4801	3594	3317	5851
Radish	2738	2811	2997	3208	3717	3633	2978	3166	2627	1858	2703	2560	2916
Rhubarb	6203	5881	5083	5952	5836	6152	6698	8122	7875	7028	10181	8708	6977
Spinach	1156	1280	1842	2493	2707	2590	1983	1677	1675	1913	2028	1191	1878
Strawberry	5288	7837	7849	16007	29608	17251	9286	6054	13311	11725	7422	6182	11485
Turnips	918	1651	1284	1417	1647	1989	1553	1548	1431	1031	993	949	1367
Potatoes	1375	1813	1854	1304	1144	990	1198	1527	1924	2124	2651	3165	1756

Table 8.2: Trade volumes of selected vegetables (Ton)

MONTH	Oct-01	Nov-01	Dec-01	Jan-02	Feb-02	Mar-02	Apr-02	May-02	Jun-02	Jul-02	Aug-02	Sep-02	Average
Asparagus	102	55	31	11	16	12	7	0	0	0	3	51	288
Beetroot	2631	2843	2657	1575	1613	1834	2178	2563	2400	2462	2672	2975	28403
Green beans	1233	1628	1317	1100	985	1370	1585	1650	1160	1243	1371	1686	16328
Broad been	23.7	4.0	0.4	0.9	0.1	0.8	2.8	1.8	1.9	1.0	8.3	19.0	64.7
Broccoli	180	157	130	125	136	130	185	246	192	263	290	149	2182
Brussels	12	2	0	1	2	3	12	35	49	49	37	15	218
Cabbage	13064	14398	11208	11438	10028	9347	10548	12099	11099	12913	14258	15044	145446
Carrot	6049	6317	5795	5020	4792	4330	4261	6074	6618	8115	7142	7027	71540
Cauliflower	1273	1147	910	835	623	707	918	1265	1422	1423	1642	1229	13394
Celery	56	50	43	47	39	37	53	80	82	72	64	56	679
Clobe artichokes	54.0	19.7	3.1	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.5	17.4	95.2
Horseradish	0.03	0.02	0.00	0.36	0.32	0.00	0.00	0.02	0.00	0.00	0.61	1.36	0.23
Lettuce	2436	2530	2397	2293	2115	2322	2159	2052	1711	2130	2417	2165	26727
Onion	21433	19248	20212	19261	17368	19143	19473	18811	17607	21150	20486	20306	234498
Peas	66	33	17	25	29	56	31	35	35	51	86	71	535
Radish	17	15	11	12	9	13	17	17	16	29	19	19	194
Rhubarb	3	3	1	2	2	2	2	2	2	3	2	2	27
Spinach	913	721	382	341	343	401	607	750	696	732	805	991	7683
Strawberry	484	144	72	14	3	6	24	86	57	137	351	478	1858
Turnips	55	39	25	25	20	25	59	151	144	148	98	63	852
Potatoes	80767	67033	65276	70483	65880	75835	76487	71841	59728	64546	56872	51316	806064

Source: NDA

However, the reader should be aware that for many of these high valued vegetables the market is limited. Table 8.2 shows the volumes which were traded on the national fresh produce markets during the 2001/2002 production year. It is clear that only small quantities of crops such as horseradish and asparagus traded. It was stated previously that the volumes traded on the national fresh produce markets only represents a portion of the total local market for vegetables. However Table 8.1 gives an indication of the relative proportion of the demand for vegetables.

Due to the considerable fluctuating markets for vegetables it is not possible to make medium or long-term predictions. However, vegetables have an inherent strong demand in the local market as part of a staple diet. At present most vegetables are highly profitable due to shortages because of inclement weather conditions. Because of the difficulty in market projections as well as the relatively high management requirement vegetables are considered to be high-risk crops. The three main vegetables grown in South Africa in terms of value of production are potatoes (R1078 mill.) tomatoes (R459 mill.) and onions (R286 mill.).

The 2002 potato harvest was approximately 7% lower than in 2001 because of frost damage in the Western Free State and the Northern Cape as well as late plantings in Limpopo. The per capita consumption of potatoes is very low compared to other countries. This creates an enormous potential for market development. However, producers should be aware of market circumstances for 2003 since the current high price will induce large plantings in 2003 with a consequent drop in prices.

At present tomato prices are under pressure due to very high prices in the previous season and an increase in local production. Onion farmers had a very bad season last year, low quality harvest and low prices. This signals an increase in prices for this season.

8.5.1 Conclusion

It is a fact that farmers react to current market conditions when they make their planting decisions. However, wise farmers will plant more when present conditions are bad and less when conditions are good because they know that the chances are good that the next season will probably be just the opposite from the present conditions.

8.6 FLOWERS

Main outlets for cut flowers include wholesale florists, retail florists, farmers markets, roadside stands and pick-your-own operations. Other possible markets include grocery stores, craft fairs, restaurants, corporations and hotels/motels. However, a large scale flower concern in South Africa will necessitate exports to international markets.

As incomes rise, more money is spent on flowers either as plants, bulbs and tubers for the garden or on cut flowers. It is also true that the price elasticity of demand for flowers is relatively inelastic. These two factors combined make flower production a financially attractive proposition.

Once a market has been found and the decision has been made to continue with a flower business, the second most important decision to make is what crop to grow. There are many factors to consider but one of the most important is to fit potential crops into the existing growing environment. Labour costs are always high when dealing with floriculture crops, and growing any plant where the conditions are not favourable leads to frustration and higher labour costs. The potential crop should also possess resistance to diseases and pests. The goal should be minimal inputs of pesticides to keep costs under control and for public relation purposes in direct product sales. The plants selected for cut flowers should ideally produce inflorescences on long stems, particularly if the target market is a retail florist. A stem length of 18 inches is often the minimum standard. Other characteristics of an ideal crop are:

- high production per square meter
- ease of harvest
- post harvest life of 7-10 days or longer
- a long production period with repetitive harvests

Annuals, herbaceous perennials, woody plants and bulbs can all be used as cut flowers/foliage. Annuals complete their life cycle in one growing season. Herbaceous perennials and bulbs are those which usually die back to the ground at the end of the growing season and resume growth in the spring. Most hardy, woody plants survive the winter season in the dormant state but do not die back to the ground as the herbaceous perennials do. Production management, harvest, pest and disease control are all different for each of these categories.

Annuals provide growers with the advantage of growing crops that are currently most popular with the consumer. With new crops being grown each season, there is less chance of disease and pest problems. Annuals typically have a longer blooming season than perennials. One potential disadvantage of annuals, however, is the higher cost associated with planting each growing season. Direct seeding would be more cost effective than starting seeds early and transplanting out into the field.

One advantage of growing perennials is they do not need to be planted each year. Soil preparation is often more critical, however, since they remain in one area for two years or more. Because of their more permanent status, they have a greater possibility of developing disease and insect problems than annuals do. Some herbaceous perennials may need to be divided and replanted as often as every two years. When dividing, more plants can be propagated from the old ones, which lowers the costs associated with purchasing new plants. Others, such as peonies, do not tolerate disturbance as well. Perennials have a shorter blooming season than many of the annuals, which can be a disadvantage.

Bulbous crops include those that grow from underground parts such as bulbs (specialized leaf tissue), corms (specialized stem tissue), tubers (specialized stem tissue) and rhizomes (underground stems). Because these types of plants usually do not branch much, they can be planted more closely than annuals or other perennials, which can lead to a higher yield per square meter of planting. When used as cut flowers, bulbs are typically treated as an annual and planted new each year. This is in contrast to a garden situation where they would be treated as perennials and left in one spot for more than a year.

Advantages of growing bulbous plants include the ease of harvest of typically leafless stems, closer planting leading to a higher yield per square foot, unique flower forms and a current strong market. Disadvantages include having to plant each season, a higher cost associated with purchasing bulbs compared to seed, and having to completely remove plant parts from the field to avoid weed problems the following season.

The volume of trade in flower bulbs and tubers is showing a steady growth and, as can be seen from Table 4.5, is driven by the flower industry in the Netherlands.

The practice by the Netherlands' flower industry to outsource the growing of bulbs and tubers is growing steadily. There are a number of South Africans already involved in such ventures. The main reasons for outsourcing are the scarcity of land (not infected with eelworm) and the cost of labour.

Table 8.3: Exports of flower bulbs and tubers (1998)

Exporting country	$'000	Rank
World	816 692	-
Netherlands	675 589	1
New Zealand	5 444	10
Brazil	3 702	14
South Africa	3 601	15
Chile	2 270	19

Source: Customs and excise – www.pathfastpublishing.com

The consultant believes that it is worthwhile considering the growing of either flower bulbs or flowers for re-export to Holland and other international markets. The SA Netherlands Chamber of Commerce has supplied the names and contact details of five flower bulb producers who would be interested in bulb production in South Africa (see Appendix 1). It is recommended that potential producers make direct contact with the individuals in Holland.

Currently, woody plants are relative newcomers to the fresh cut floral market. A large potential market exists for just the right product. One advantage that woody plants have over annuals, herbaceous perennials and herbs is the different stages that can be harvested and used. In the winter bare branches with attractive bark or buds could be harvested; spring and summer yield flowering branches; fall provides autumn colours of foliage as well as berries which can be used either fresh or preserved. Woody plants live for many years without needing division or disease and pest management that herbaceous perennials require. Established farm shelter belts or mature landscape plants could yield an abundance of usable material. New plantings, however, may take two years or more to begin yielding a marketable product.

Woody plants carry some disadvantages as well. More knowledge of growth habit is required by the harvester to ensure continued success the following seasons. One important thing to note when harvesting flowering branches is whether or not the particular species blooms on current wood or one-year-old wood. Branching habit will also be affected by the type of pruning done. Because woody plants are relatively new to the fresh cut flower and foliage industry, knowledge on post-harvest care is lacking and it may be up to the grower to experiment and find techniques to contribute to a longer vase life of the product.

8.6.1 Conclusion

At best, the market is a dynamic target with consumers constantly changing their preferences. Becoming and staying informed is critical to any marketing plan. To be a continual success, the grower must be willing to shift production to meet consumer preferences.

The consultant is of the opinion that there are major opportunities especially for flower bulbs for export to the Netherlands.

8.7 STONE FRUITS

This section covers the export market for apricots, plums, nectarines and peaches. An international overview will give the reader a background on Southern Hemisphere competition as well as South Africa's most important markets. This is followed by a section on stone fruit production in South Africa.

8.7.1 International overview

Table 8.4 represents Southern Hemisphere production of stone fruit during 2002. It is clear that South Africa is the third largest (19%) producer of stone fruit in the Southern Hemisphere. However, with regard to apricots SA is the largest producer in a Southern Hemisphere context.

Table 8.4: Southern hemisphere production (2002)

Production (Mt)	*Apricots*	*Peaches and Nectarines*	*Plums*	*Total*	*% Contribution to Southern Hemisphere Production*
World	**2,738,601**	**13,413,343**	**9,141,808**	**25,293,752**	
Southern Hemispher	**153,383**	**1,021,626**	**361,829**	**1,536,838**	
Argentina	19,500	252,263	105,475	377,238	25%
Chile	44,000	249,400	180,000	473,400	31%
South Africa	61,488	185,300	38,329	285,117	19%
Brazil		184,000		184,000	12%
Australia	20,000	90,000	22,000	132,000	9%
Peru	165	26,466	6,745	33,376	2%
New Zealand	7,000	11,015	2,000	20,015	1%
Uruguay		13,682	3,800	17,482	1%
Madagascar	1,200	7,500	1,800	10,500	1%
Paraguay		1,250	1,500	2,750	0%
Zimbabwe	30	750	180	960	0%

Table 8.5 represents the area under stone fruit production. South Africa shares the third place in terms of area cultivated after Argentina and Chile. Although Australia is in the third place they do not compete in the same markets. Most of the Australian stone fruits are exported to Asian countries. Also, although Brazil shares the third place with South Africa, they consume most of the domestic produced cultivars. Although Argentina is the largest producer of stone fruit, most of the crop is either consumed domestically or exported to the USA. South Africa's main competitor is Chile. The remainder of the section on stone fruit will therefore concentrate on Chile. However, it is also important to briefly discuss developments in the other South American countries since it is possible that they may become important competitors in future.

Table 8.5: Southern Hemisphere stone fruit production area (2002)

Area Harv (Ha)	*Apricots*	*Peaches and Nectarines*	*Plums*	*Total*	*% Contribution to Southern Hemisphere Production*
World	**377,817**	**2,190,498**	**2,299,849**	**4,868,164**	
Southern Hemispher	**14,741**	**100,340**	**38,015**	**153,096**	
Argentina	2,150	23,500	14,000	39,650	26%
Chile	2,800	17,800	13,000	33,600	22%
Brazil		23,000		23,000	15%
South Africa	5,800	12,000	5,000	22,800	15%
Australia	3,100	13,000	3,110	19,210	13%
Peru	45	4,500	1,180	5,725	4%
Madagascar	130	3,000	420	3,550	2%
Uruguay		1,850	650	2,500	2%
New Zealand	700	1,300	350	2,350	2%
Paraguay		200	250	450	0%
Zimbabwe	16	190	55	261	0%

Table 8.6 shows exports from Southern Hemisphere countries. Chile exports represent almost 72% of total Southern Hemisphere exports. Although South Africa only represent 16.8 percent of total SH export it is clear that apricot exports are substantially higher than those of Chile (5000 ton compared to 3700 ton). Also, although Argentina is the largest stone fruit producing country, they are only responsible for 5.5 percent of total Southern Hemisphere exports. Although, Australia are in the third place with 6.1 percent of total exports they are not competing in the European and UK market. Although, Chile exports the largest volumes the reader should be aware that a significant proportion of these export are destined for the USA market and therefore do not compete directly with South African fruits in the UK and European market.

Table 8.6: Southern Hemisphere stone fruit exports

Export tonnes	*Apricots*	*Peaches and Nectarines*	*Plums*	*Total*	*% Contribution to Southern Hemisphere Production*
Southern Hemisphere	**8,996**	**122,316**	**151,381**	**282,693**	
Chile	3,700	104,365	94,305	202,370	71.6%
South Africa	5,000	7,400	35,000	47,400	16.8%
Australia	243	6,800	10,300	17,343	6.1%
Argentina	53	3,609	11,776	15,438	5.5%
New Zealand		142		142	0.1%
Zimbabwe		77	22	99	0.0%
Peru		35		35	0.0%
Brazil		5	5	10	0.0%

Argentina

The following is the main characteristics of the Argentina stone fruit industry are (Trade Latin America, 2002):

- Population of 37 million
- Total GDP US$285 billion
- GDP per capita US$7 695 (2002)
- Second largest producer of stone fruit in the world
- Most of the production is consumed locally.
- Total stone fruit production is 377 000 ton, however they only export 15 500 ton
- Argentina's largest stone fruit export market is Brazil
- Main export stone fruit exports are plums, nectarines and peaches.

Brazil

The Brazilian industry are characterised as follows (Trade Latin America, 2002):

- Population 165.9 million
- Total GDP US$624.3 billion
- GDP per capita US$3 760
- Fourth largest stone fruit producer
- Mainly peaches and nectarines
- More into subtropical fruit
- Relative large stone fruit imports: plums 1 500 t, Nectarines 3 300 t, Apricots 330 t
- Exports insignificant

Chile

South Africa's main competition is Chile. Chile's key economic statistics are as follows:

- Population 15.2 mil
- Total GDP US$70.2 billion
- GDP per capita US$14 172

Chile’s fruit exports have expanded strongly since the 1970s, becoming one of the pillars of Chile’s economy. Aside from traditional mineral outputs that have dominated the country’s exports for decades, Chile now exports fresh fruit and vegetables of over US$1 400 million FOB a year (Brown, 2002).

Although Chilean fruit production dates from the 1930s, the first sustained fruit exports came hand in hand with the technological developments of the 1950s, which allowed massive shipments in refrigerated ships. Later, during the 1970s, Chile initiated a process of accelerated development that set the foundations of a real fruit industry. This industry had its base in the natural conditions that have always been available in the country, and it drew on the important changes in economic policies that had been applied until then. The result was the replacement of traditional crops with a new, labor intensive industrial activity that required qualified workers, as well as significant investments in modern infrastructure and the input of foreign entrepreneurs. Undoubtedly, this was due to the fact that farmers now had the possibility of taking on long term projects as a consequence of the climate of stable and non-discriminating policies that had emerged. This is how the Chilean fruit export industry came to be. It is an industry whose evolution has been the subject of much analysis and which has surprised many with its extraordinary results (Bown, 2002).

The state took on a subsidiary role in relation to incentive mechanisms, leaving the challenge of managing risks in the hands of business. Chile is blessed with professionals possessing great ambition and management skills. These businessmen have taken on great challenges involving changes that on occasion have verged on the dramatic. Their daring has made possible a major evolution in Chilies exports, rising from a total of US$168 million in 1980 to US$1 400 million in 1996. This represents growth by a factor of of 8.3 in 15 years. A picture of the fruit industry today in Chile is one of approximately 12 000 producers, 700 export companies, US$1 400 million in FOB returns, 179 000 hectares planted, 55 horticultural and fruit species exported, 829 shipments in the last season, 385 high technology cold storage facilities, 100 fruit centers and over 1 000 satellite packing centers. In all, there are about 850 importers of Chilean fruit in over 60 countries (Bown, 2002).

Chile’s main export products are grapes, kiwi, apples, pears and stone fruit. The main export fruit is table grapes, which represents approximately 40% of the total volume exported. The main destination for exports is the United States, which receives approximately 36% of total fresh fruit exports. Europe, as a whole, follows the US closely with 35% of total exports. Over the past few years Chile have experienced a major growth in exports in two regions of the world, Latin America and the Asia-Pacific. In the mid-1960s, Chilean exports of table grapes, apples and pears were only 3.5% of the total Southern Hemisphere exports of those products. Chile has since increased its share to 48% overall. Chile represents 80% of the grapes, 37% of the apples and 33% of the pears and 71.6 % stone fruit exported by the Southern Hemisphere. For several years now, Chile has been the largest exporter of table grapes worldwide. This is a clear reflection of Chile’s successful horticultural and fruit export drive. They have chosen to stimulate private enterprise in an environment of complete freedom. The final outcome is the result of thousands of individual initiatives that have accumulated over time and that have brought hundreds of new producers and exporters in to the industry. All this has taken place through a perfectly natural process, with no centralized direction or instructions from the State.

Chile versus South African exports

Apricot exports from Chile are insignificant. Figure 8.7 compares the distribution of plum exports of South Africa with Chile. It is clear that South Africa is much earlier in the market compared to Chile. Also, the cultivar spread is significantly better in South Africa. This enables SA to supply the market with more constant volumes, thus giving SA a competitive advantage.

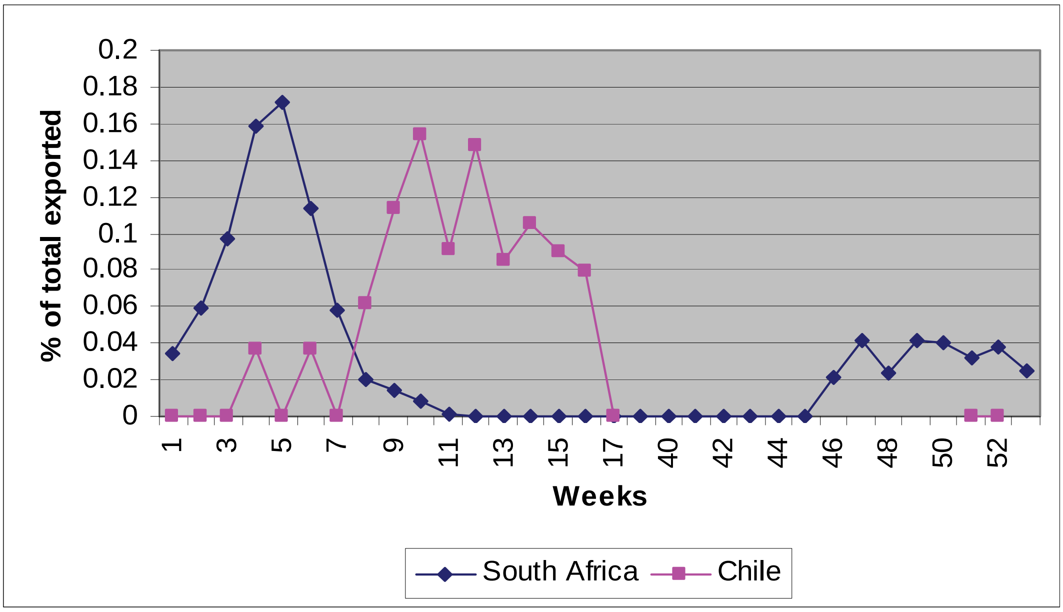


Figure 8.7: Chile-SA plum export to Europe and the UK

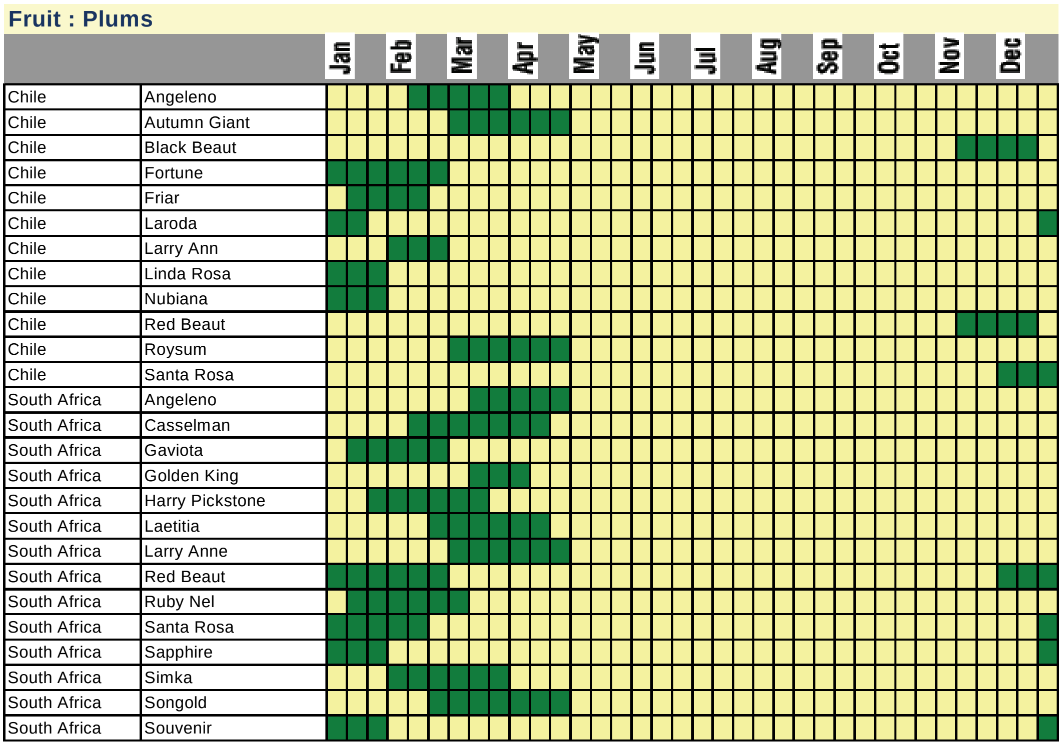


Figure 8.8: Plum cultivar availability in the UK and European market

It is clear from Figure 8.8 why South Africa is in a more competitive position compared to Chile. South Africa's cultivar combination enables the country to supply the markets over a longer period. Figure 8.9 represents the percentage of total peach exports from Chile and South Africa to the UK and Europe. It is clear that there is no competition for the same marketing time slot. South Africa is early in the market compared to Chile.

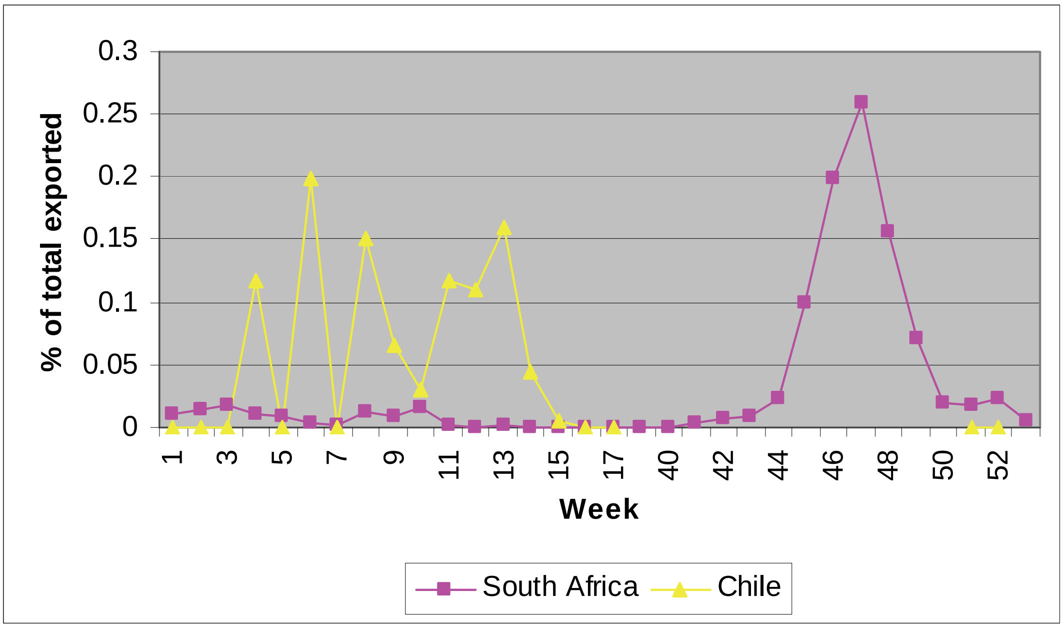


Figure 8.9: Chile-SA peach exports to Europe and the UK

Figure 8.10 shows the cultivar availability of South African and Chilean peaches. It is clear why South Africa is in a much stronger position in the early part of the market time slot compared to Chile.

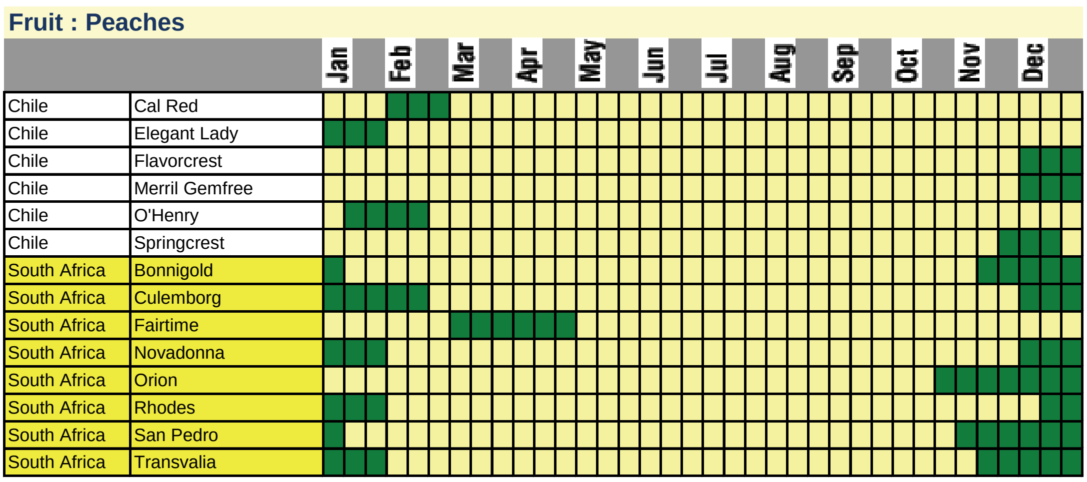


Figure 8.10: Peach cultivar distribution

Figure 8.11 represents the marketing time slots for nectarines. The figure clearly shows that there is only competition in the later part of the season (week 1 to 9). During the early part of the season there is no competition from Chile. It is also interesting to note that the South African volumes are more evenly spread.

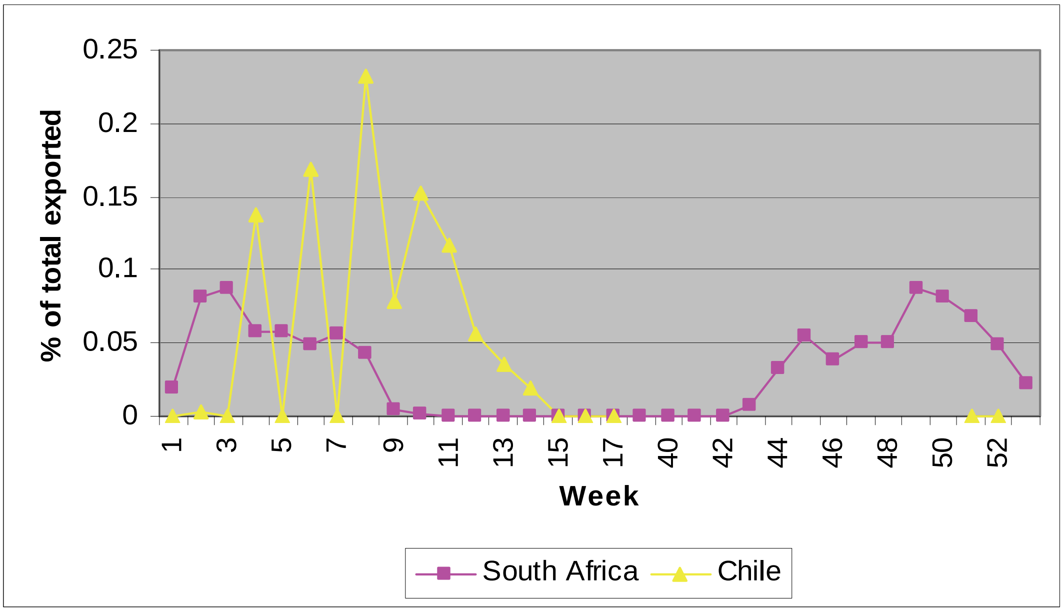


Figure 8.11: Chile – SA nectarine exports to Europe and the UK

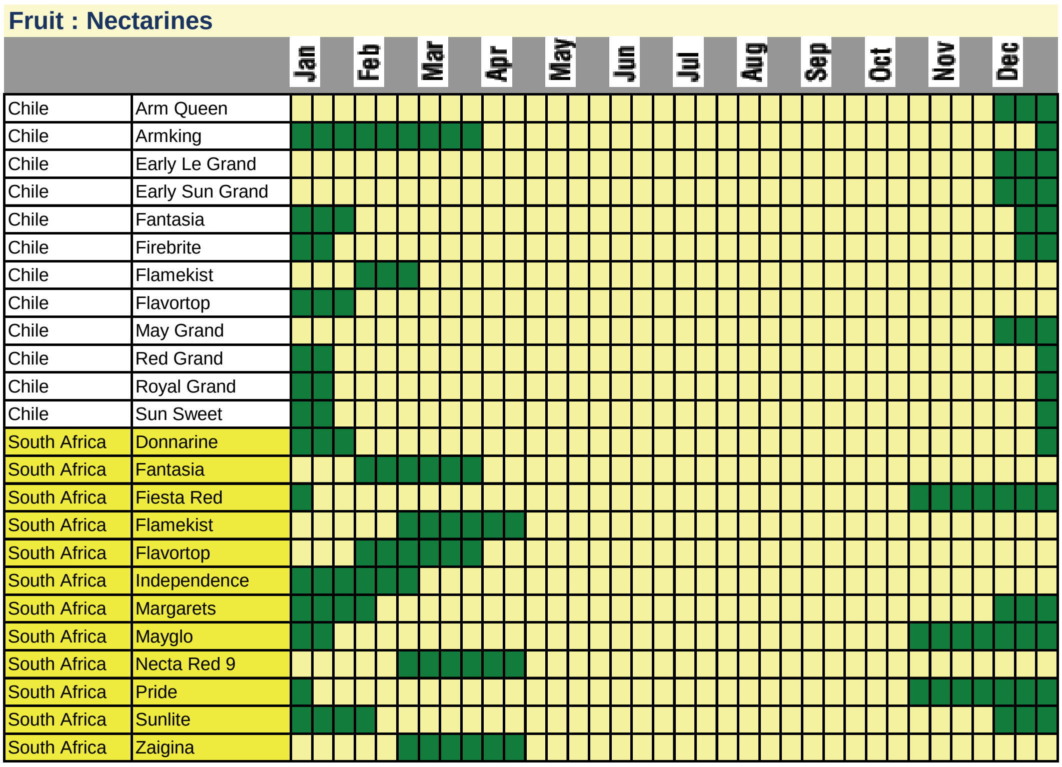


Figure 8.12: Nectarine cultivar availability in the UK and European market

Figure 8.12 clearly shows why competition during the early marketing time slot from Chile is stronger with nectarines compared to the other stone fruits. However, it is also clear that similar to the other stone fruits Chilean availability is fluctuating much more compared to South Africa's more even spread.

8.7.2 South African Industry

The Deciduous Fruit Producers' Trust has endorsed the Eurogap guidelines on good agricultural practices in order to meet EU requirements for food safety, minimum residue levels, and tracking of consignments. South Africa's fruit export industry has experienced dramatic changes since 1997 after marketing deregulation.

The fruit industry launched a new international umbrella campaign during 2001, under the slogan "Fruit South Africa", designed to promote South Africa as a high quality producer among importers and consumers around the world. South Africa, Australia, Argentina, Chile, New Zealand, and Brazil, established a Southern Hemisphere Fresh Produce Exporters Forum (SHAFE) to address serious concerns in the industry such as the imbalances between demand and supply, variety adjustment, critical price situation, absence of new emerging markets, and the increased role of food safety and standardization in food trade. This association was formally launched in January 2000 and will hopefully have a positive impact on the deciduous fruit industry since market information will be exchanged.

8.7.2.1 South African stone fruit area

The combined stone fruit area in South Africa contributes approximately 25 percent of the total fruit area. Plums and apricots contributes approximately the same area (6%), peaches dominates with a 12% contribution. Nectarines only contribute 2% to the total area.

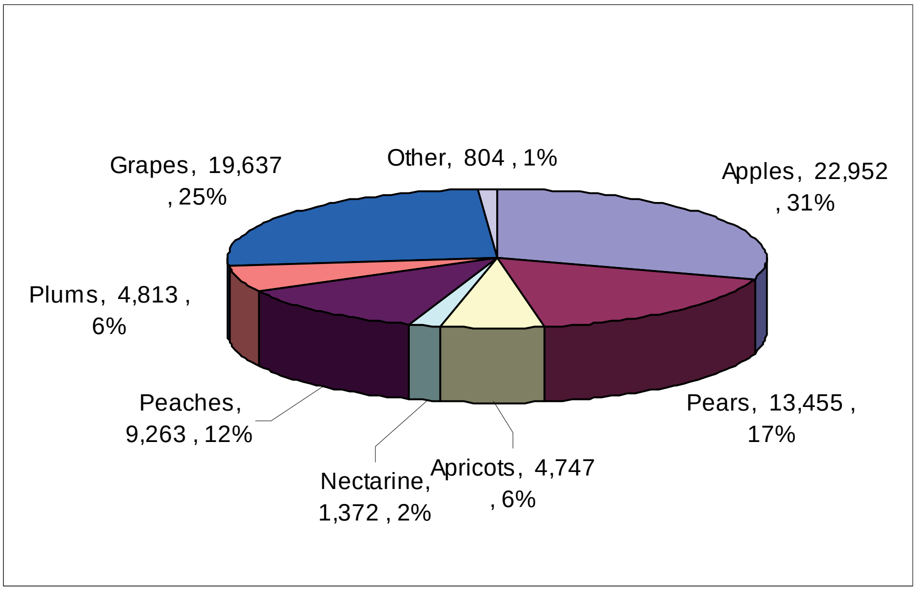


Figure 8.13: Contribution of deciduous fruit to total area

8.7.2.2 Stone fruit exports

The majority of South African apricots are exported from week 45 to week 52. Also it is clear from Figure 8.14 that peak production is during week 48 when approximately 250 -300 000 cartons are ready for exports. Most of this fruit will reach the UK and European markets two weeks later in weeks 50 to 51.

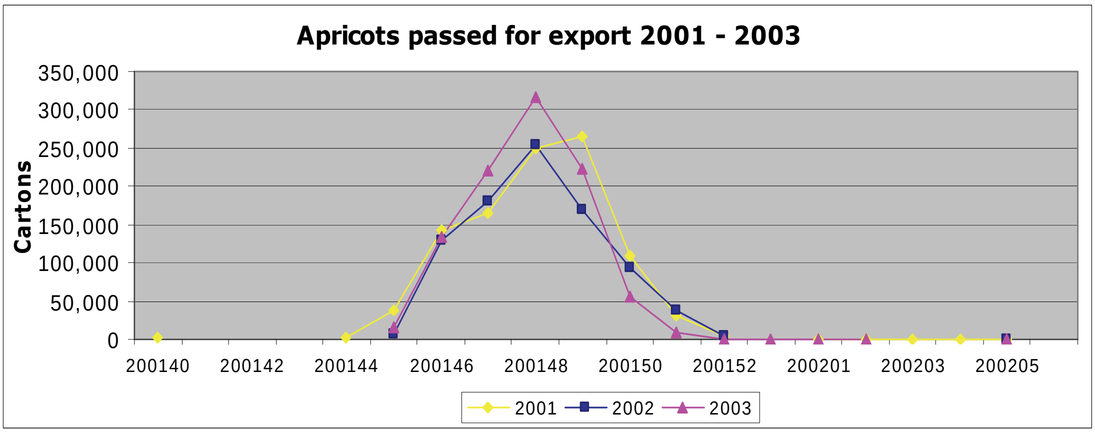


Figure 8.14: Apricots passed for exports

Figure 8.15 represents the intakes (at pack facilities) during the season. Plums are exported over a much longer period compared to apricots. The majority of plums are available from week 45 to week 12. Peak production fluctuates between seasons but is normally during week 5 to 7. The South African cultivar mixes are particularly good since plums are available for 5 months of the year. South Africa is recognised as a preferred supplier of plums in most of the export markets.

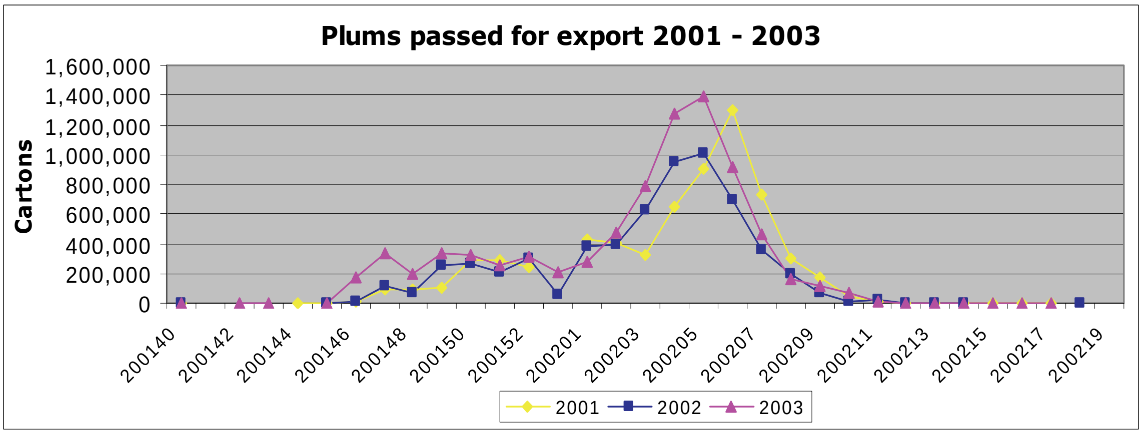


Figure 8.15: Plums passed for exports

South African nectarines, although only available in small volumes, are also spread over a long marketing season. The export season commences during week 41 to 42 and ends during week 11 to 12. It is clear from figure 16 that there are two peaks. The first during week 49 to 51 (depending on the season) and the second during week 4 to 7. This is because of relatively early and late cultivars.

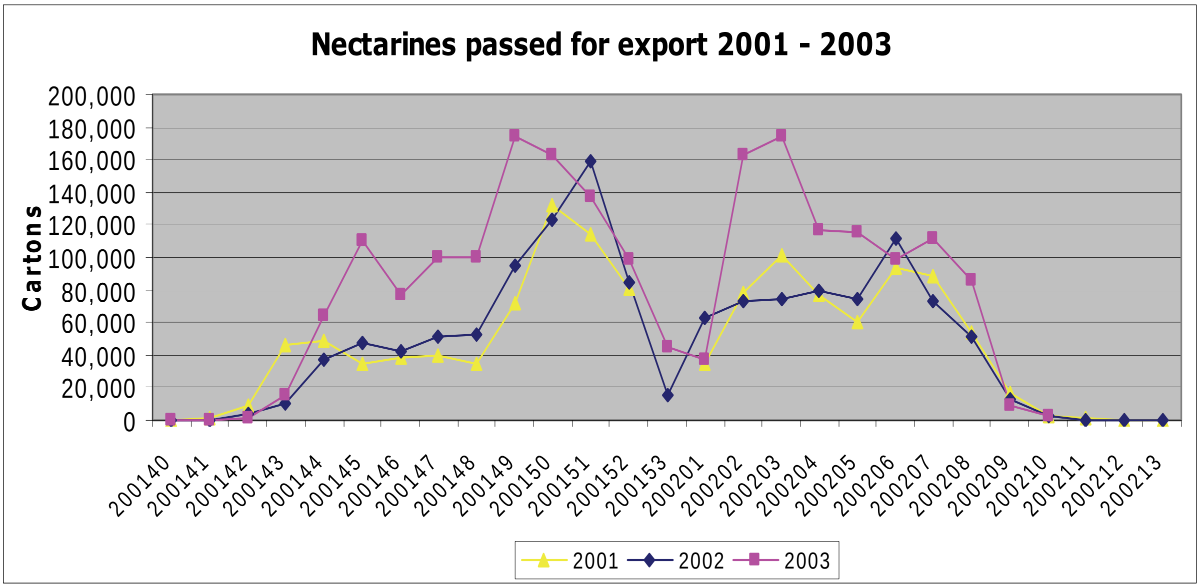


Figure 8.16: Nectarines passed for exports

Most of the South African peach exports are over a relatively short period (week 46 to 49).

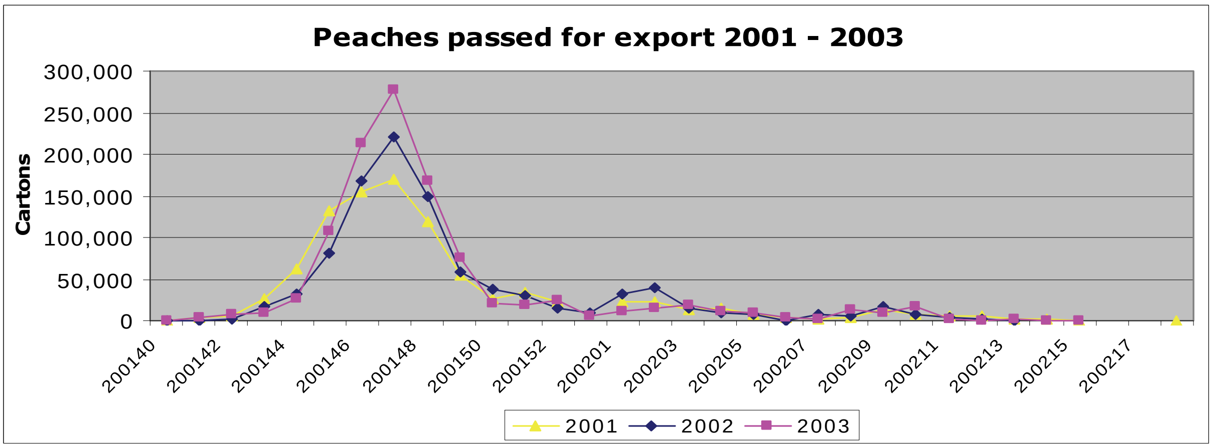


Figure 8.17: Peaches passed for exports

8.7.3 Conclusion

The South Africa stone fruit industry has several advantages above many of its competitors. These are:

- For most of the cultivars we are early in respect to production of similar cultivars in Chile.
- Own bred cultivars (unique).

- Relatively good infrastructure.
- Advanced cold storage techniques.
- Well placed with regard to Europe, Middle East.
- Traditional SA produce fruit with high eat quality

The consultant is of the opinion that there is an improved perception of SA fruit as a whole in the market after the chaotic marketing seasons following deregulation. Opportunities are there to make a success of SA Stone fruit industry.

8.8 BERRIES

This section covers a general discussion on berry marketing and production.
However, the main focus of this study centers around three crops:

- strawberries
- raspberries
- cranberries

The location of a berry farm is important. Consideration should be paid to the proximity of urban centers (if selling direct to consumer), the climate (heat pockets, wind, etc.), soil conditions, air/soil drainage, and shelter. All berry crops prefer soils with a high level of organic matter. Strawberries perform best on sandy loam soils, raspberries on loam to clay loam, and black currants and saskatoon on most soils.

Adequate shelter is very important to berry production. Shelter should be placed to reduce the prevailing winds of summer and winter. Shelter reduces desiccation (drying), improves snow coverage and provides winter protection.

Irrigation is a must for berry growers to obtain the maximum production potential from plants. Trickle or drip irrigation is effective and cost-efficient for raspberries and cranberries. However, strawberry growers should investigate sprinkler irrigation if at all possible. Due to the close row spacings of strawberries, trickle irrigation can become costly. Sprinkler irrigation also assists in the incorporation of herbicides, field cooling, and frost protection of strawberries. Water sources, quality and quantity should be evaluated before planting.

An international review of literature revealed that the majority of berry production is presently sold through u-pick operations. Requirements for u-pick operations include the proximity to large population centers, all-weather roads, adequate parking, and adequate signage.

Both raspberries and strawberries are extremely perishable. Fresh berries should reach consumers within two days (48 hours) of harvest with cooling, one day if cooling facilities are unavailable. The marketing activities for most berry operations focus on selling fresh berries, directly to consumers. Fresh berries must be picked at least every other day during the harvest, be handled as little as possible and cooled immediately after picking. Immediate cooling after harvesting is necessary to remove the field heat. This reduces flavor loss and extends shelf life. As a result, marketing opportunities for fresh berries are limited by both the distance they can be shipped and their short shelf life. The primary requirement for a commercial berry farm is close proximity to a large urban population. A general rule applied in the berry industry is that every ha of production requires a population of 4 000 middle to high income group people within a 100 km radius (with no other competition). Because there are fewer ha of raspberries, consumers may travel further for raspberries than for strawberries.

Generally, the demand for fresh berries is greater than the available supply during the growing season. However, every local market area has its own unique supply and demand characteristics. New entrants must identify the market area they are considering selling to and determine if this market has room for additional production. Raspberries and strawberries are preferred fruits. This means they will sustain a greater level of demand at higher prices than most other fruit in the same price range.

New entrants must be prepared to gather as much knowledge and information as they can about the consumer markets for fresh fruits and berries in their area. The focus of market research should be on determining consumer trends in fruit consumption, what berries are desired by consumers, the number of competitors in the market area, evidence of excess supply and trends of declining consumption or declining prices.

The production costs for individual enterprises vary due to factors such as location, crops, size, machinery, labor use and marketing activities. New entrants must be prepared to estimate the costs and returns for the specific operation(s) they are considering putting into place. New entrants should also develop budgets to determine if they have adequate resources to survive a poor year.

Figure 8.18 represents the volume of strawberries and average price levels on the national fresh produce markets. It is clear that price levels fluctuates between R5 000 and R30 000 per ton depending on availability. Volumes peak during August, September and October.

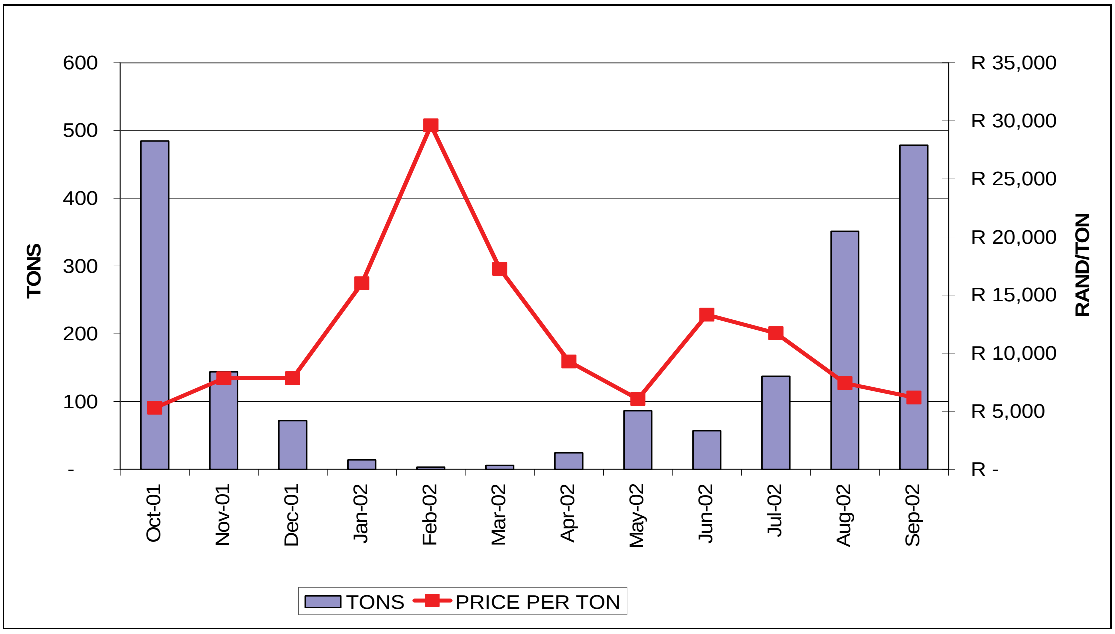


Figure 8.18: Strawberry volumes and price on national fresh produce markets
Source: NDA

Figure 8.19 represents the raspberry trade volume and price levels. It is clear that volumes peak during February and March and that extremely high price levels is possible in the early and late part of the season. However, it is also clear that trade volumes are relatively low.

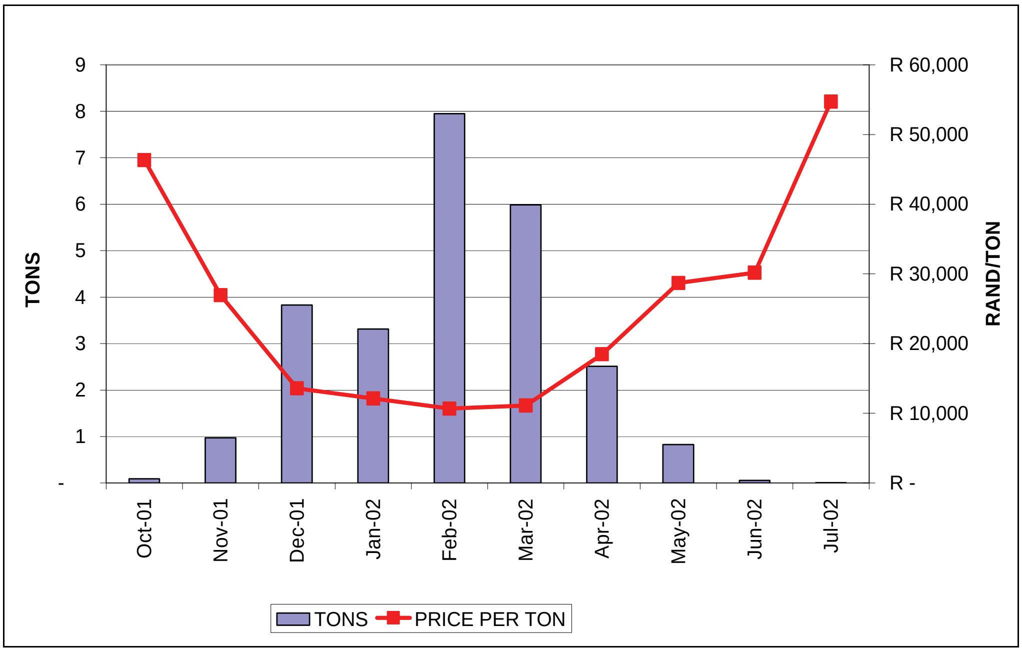


Figure 8.19: Raspberry volume and price on national fresh produce markets
Source: NDA

Although gooseberries are not on the list of identified crops, they are similar to cranberries.

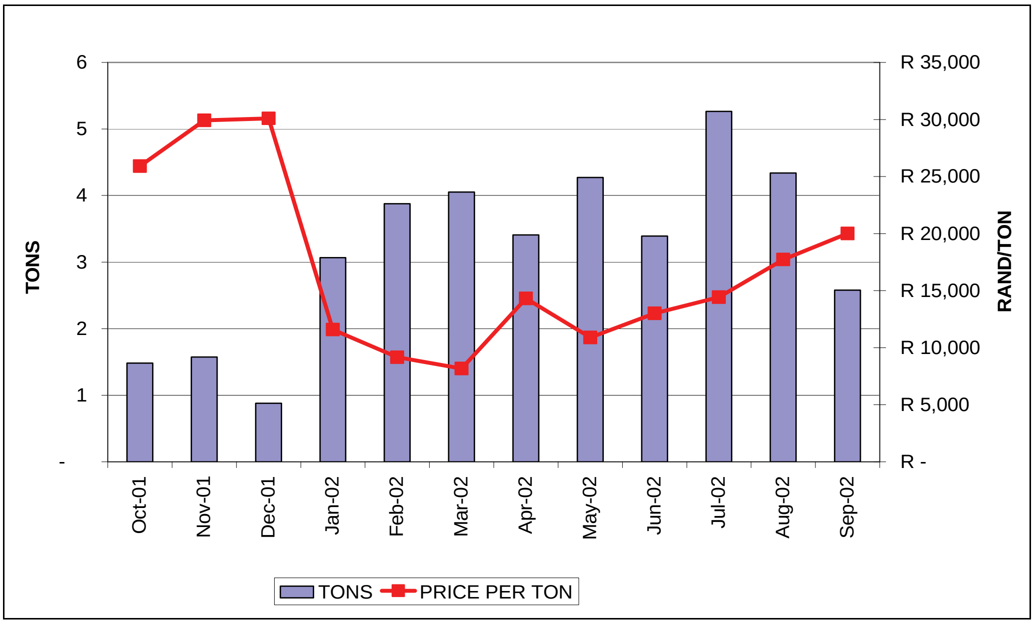


Figure 8.20: Gooseberry volume and prices on national fresh produce markets
Source: NDA

8.8.1 Conclusion

The critical marketing issues for berry farmers seeking to sell fresh berries directly to consumers are the proximity of the berry farm to potential consumers, gaining market exposure and consumer awareness, providing high quality products and ensuring that customers have a pleasant experience.

The envisaged project is in close proximity of the Johannesburg and Pretoria metropolis and therefore complies with the most important prerequisite for berry production. Also, berries are a high value crop with the ability to pay for the high cost of water purification. However, berry production needs a high level of good management.

8.9 FIELD CROPS

Although Kikuyu and Lucerne were identified as potential crops for the purpose of this study, the author is of the opinion that both these crops are not profitable enough to cover the expected high cost of water purification. However, it could be possible to grow Kikuyu to sell as instant lawn. Since there is no information available on the industry this possibility was not explored. Maize and wheat production in a double cropping system could be profitable depending on product prices. The remainder of this section will deal with these crops.

8.9.1 Maize

8.9.1.1 International

Figure 8.21 represents world maize production. It is clear that production increased steadily from 1992 to 1998 when it stabilized at around 600 million tons. Since 1999 a steady decline followed and during 2002 production was round about 580 million ton.

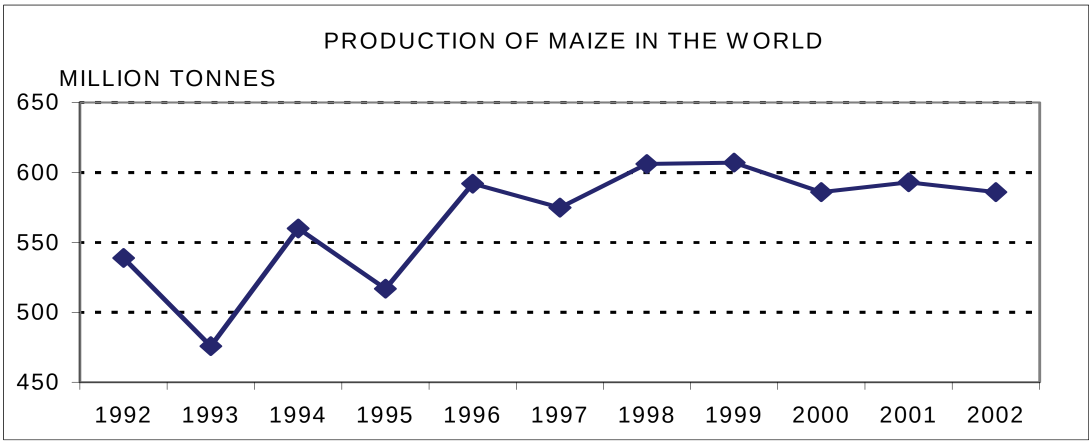


Figure 8.21: World maize production
Source: USDA (2003)

Table 8.7 shows the largest producers of maize in the world and their harvesting time, which is normally the time when prices are under downward pressure.

Table 8.7: Largest producers of maize in the world.

Country	2000/2001 (Kt)	2001/2002 (Kt) (estimated)	2002/03 (projected)	Harvesting time
United States	251,85	241,49	228,80	September-November
China	106,00	114,09	125,00	August-October
EU	37,82	39,69	39,44	September-November
Other	192,62	203,45	200,72	-
World total	**588,29**	**598,72**	**593,958**	**-**

Source USDA (2003)

The Northern hemisphere countries produce the largest volume of maize in the world. The market share of the US is expected to decrease in 2002/03 to 38% against 43% of the 2000/01-season. China on the other hand gained on the US as their market share increased with more than 3% to 21,3% in the same period as mentioned above. It is also clear that US production is declining with the production figures of other countries in a slow growing trend. Most of the harvesting of maize in the world takes place during September – November and the USA is the largest driver of maize prices (and exports) via the Chicago Board of Trade. Table 8.8 gives a summary of the world supply and demand estimates for maize.

Table 8.8: World supply and demand estimates

World maize (million ton)	1999/00	2000/01	2001/02	2002/03
Beginning stocks	169,12	171,04	153,91	132,49
Production	606,77	588,26	598,72	593,95
Imports	79,98	75,62	73,98	74,36
Feed consumption	421,38	426,15	437,76	433,59
Total consumption	604,43	605,40	620,15	619,72
Exports	85,78	77,33	75,26	74,36
Ending stocks	171,47	153,91	132,49	106,73

**Source USDA (2003)*

It is clear that ending stocks in the world is at its lowest levels since 1999/2000. Figure 8.22 shows the declining production of maize in the USA.

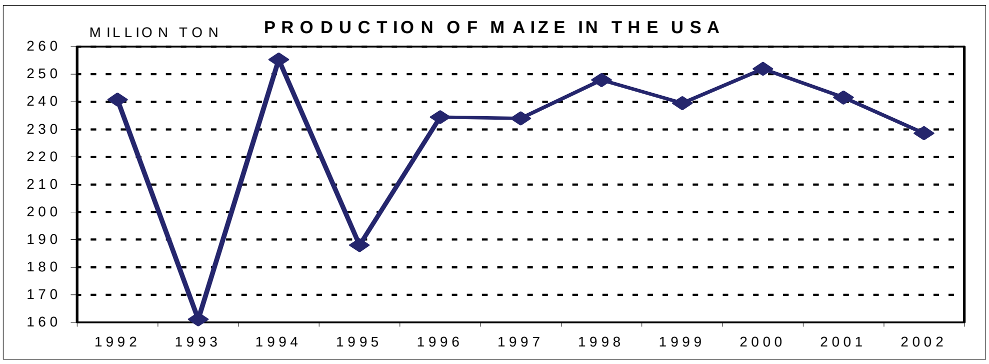


Figure 8.22: Maize production in the USA
Source: USDA (2003)

Stocks in the USA dropped with the largest margin in this period with 41,55%. The situation in China shows a sharp decline as the projected stocks in 2002/03 is 35,5% lower than the stocks of the 2000/01 seasons. The stock situation in the EU is expected to drop only marginally.

Table 8.9 explains the current low stock levels. It is clear that although total usage remained relatively constant over the period 1999-2003 supplies dwindled from 295 million ton in 2000/2001 to an estimated 269 million ton in 2002/2003.

Table 8.9: US supply and demand (million ton)

	1999/00	**2000/01**	**2001/02**	**2002/03**
Beginning stocks	45.39	43.63	48.24	40.55
Production	239.55	251.85	241.49	228.8
Imports	0.38	0.17	0.26	0.38
Total supply	***285.32***	***295.65***	***289.99***	***269.73***
Feed use	143.9	148.4	149.27	142.25
Food/Seed/Industrial	*48.6*	*49.7*	*52.18*	*57.53*
Exports	49.19	49.31	47.98	44.45
Total usage	***241.69***	***247.41***	***249.43***	***244.23***

Source: USDA (2003)

It is estimated that that producers are going to increase their plantings of maize in the 2003/2004 season. Producers usually decide between maize and soybeans but the large soybean crops in South America left US producers with not much alternatives and plantings of maize could increase.

The USDA (2003) is expecting an increase of around about 1,5 million acres in maize production, with a similar drop for soybeans. The current production is the lowest figure in many years but an increase is expected because of the maize plantings in the USA during the new season. Production figures in China are on the increase as a result of government efforts. China is planning to expand plantings in an effort to be self-sufficient in the next five years.

The information on world supply and demand indicates clearly that world consumption of maize is in a relatively sharply growing trend. Consumption in the current season stabilized a little bit but growth is expected in the years to come and just the growth in the world population is enough reason for a larger demand as maize is one of the best and most affordable sources of food. The consumption of maize in the world increased with roughly 3 million tonnes per annum but between the 2000/01 and 2001/02 season a relative sharp increase occurred with a jump of more than 12 million tonnes.

World consumption consists of basically three sectors with the feed sector the largest one – it is expected that it will have a market share of ±70% in 2002/03. In the 1999/00 season the share was marginally lower on 69,7%. The 12 million tonnes increase in world consumption which was mentioned earlier mainly occurred in the feed sector. The food, seed and industrial sector follows the feed sector as the next most important source of demand with an expected market share of ±18%. This figure was almost 2% lower in the 99/00 season at 16,1%. If the consumption figures of the 99/00 season are compared with that of the latest season, it is clear that consumption in the world is increasing at a faster rate than that of the USA consumption. World growth is 2,5% compared to only 1.05% in the USA. The growth in world population is the major driver of increases world demand.

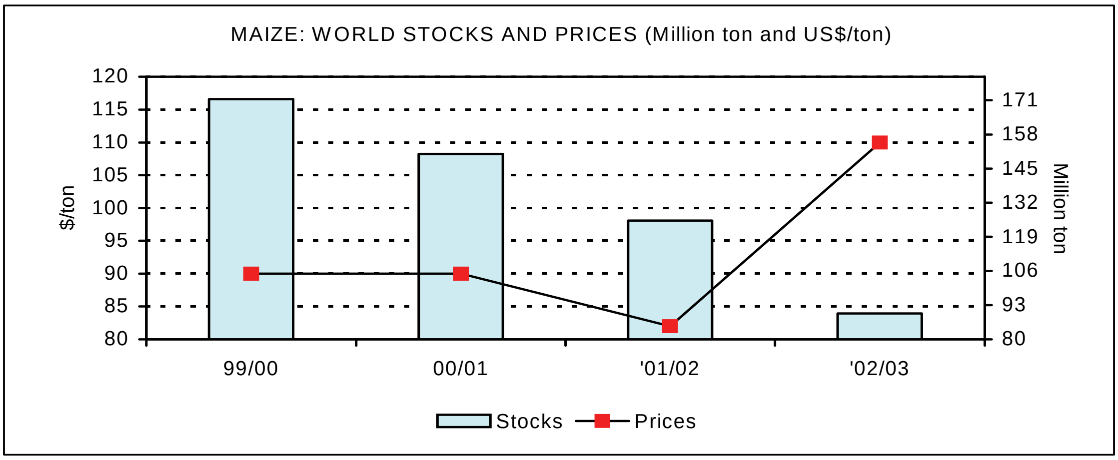


Figure 8.23: World maize stocks and prices
Source: USDA (2003)

Figure 8.23 shows a strong correlation between world stocks and the international price for maize. It is expected that it will take a year or two of larger than normal production figures to bring production in line with the world demand. It is still too early to predict but it seems as if the price of maize is going to increase to higher levels over the short-term. The only reason for that is the low stock situation of maize in the world. The price of maize will depend to a large extent of the plantings and therefore production of maize in the Northern Hemisphere.

8.9.1.2 South Africa

Total maize production

Figure 8.24 shows the trend in SA area planted and crops sizes since 1987/88.

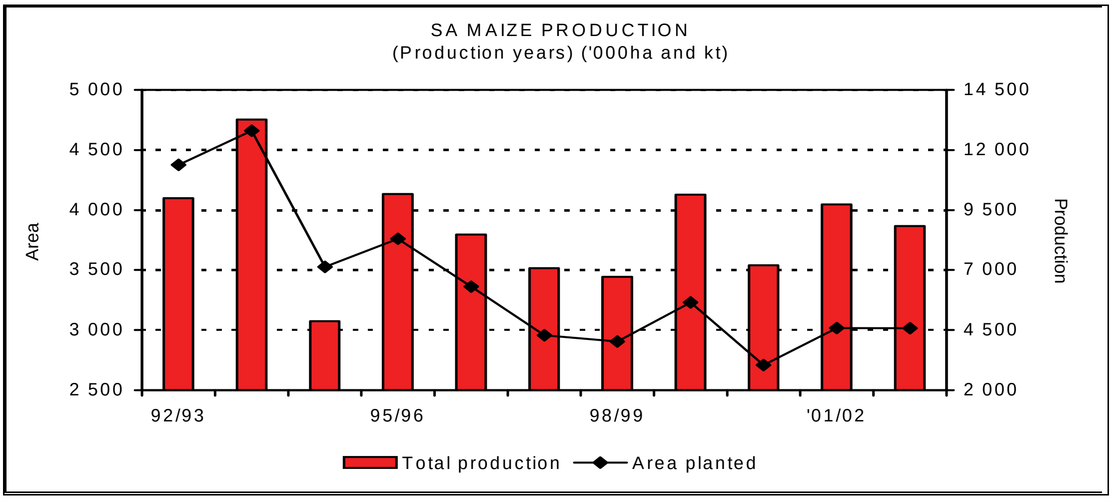


Figure 8.24: South African production

The volatility of both the area planted as well as production is clear. A trend line should show a definite downtrend in the area planted with maize but production should show the opposite with a slow growing trend. There are different reasons for this which will be discussed later in this document.

To illustrate the huge differences in the area planted and production the plantings of maize in the last ten seasons are discussed. Producers planted 4 377 million hectares of maize in 92/93 and that figure dropped in the last ten seasons to 3 015 million hectares – a decrease of more than 31%. If the highs and the lows are compared, the figures differ even more – a difference of 1 953 million hectares between the two seasons. The difference between the best crop and the smallest crop is 5 275 million tonnes and these huge fluctuations make it very difficult for all role players in the domestic market.

Yellow Maize

The plantings of yellow maize dropped substantially during 2002/2003. It is estimated that the plantings of yellow maize for the 2002/2003 season dropped with more than 47% compared with an all time high during the 94/95 season.

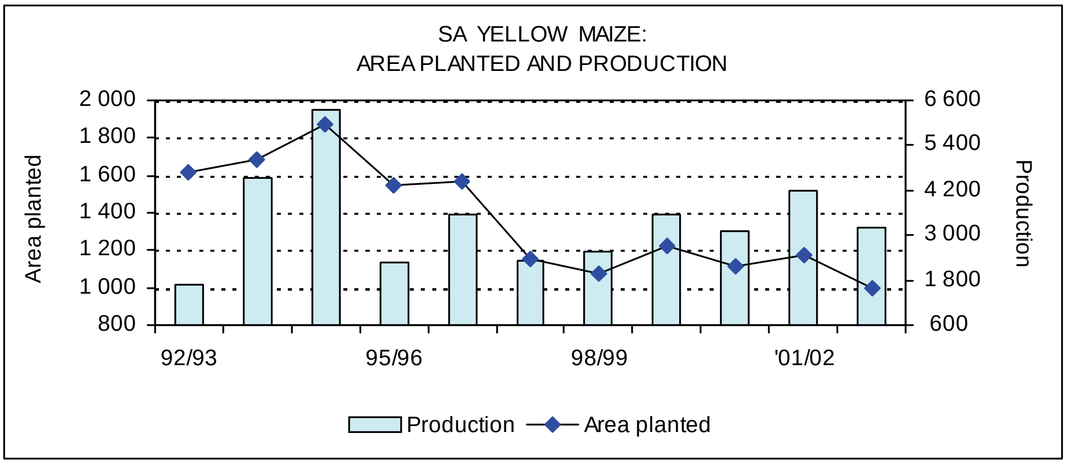


Figure 8.25: Yellow maize area trend
Source: AMT (2003)

The reason for the decrease in plantings of yellow maize is the increase in white maize plantings and the high price of white maize during planting time. The area planted with yellow maize during 2002/2003 was ±27% less than the average of the last ten years, which means that there is room for a turnabout in yellow maize production.

The Free State is still the area where the largest plantings took place in the last five seasons with Mpumalanga in second place and the Northwest Province third. Production tells another story with the best production figures and therefore yields in Mpumalanga. Production of yellow maize is second best in the Free State with the Northwest in third place.

White maize

Figure 8.26 represents the production of white maize in South Africa. White maize plantings, according to the latest crop estimates, shows an increase in plantings this season and the shift from yellow production to white maize production is one of the reasons for this trend.

It is clear that the area planted is relatively volatile but in contrast with yellow maize plantings, the difference between the largest and the smallest plantings is only 21%. In the case of production this change quite dramatically with a difference of almost 80% when the best production year is compared with the lowest production figures.

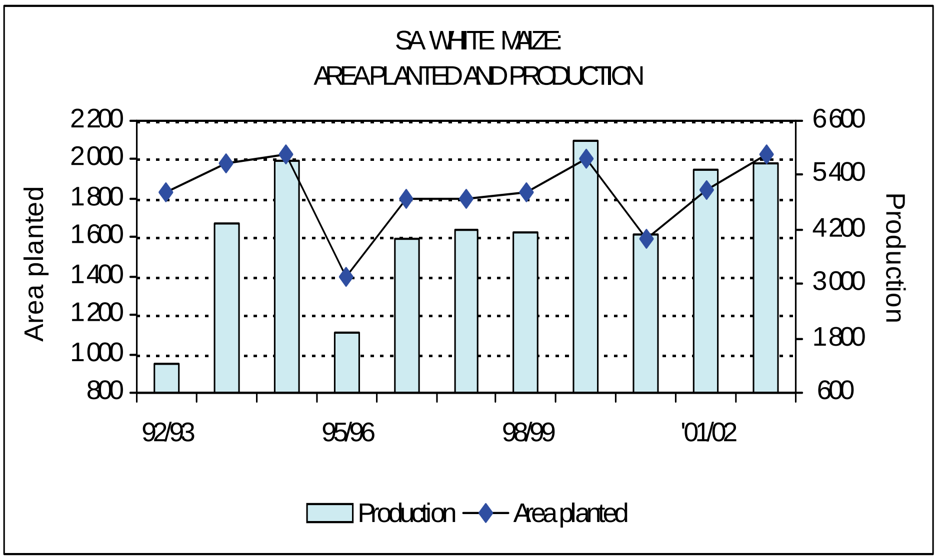


Figure 8.26: South African white maize production

Plantings of white maize in the 2002/2003 season were ±10% better than the ten-year average and production is almost 32% higher than the long-term average. Better growing conditions, better cultivars, better cultivating practices and other factors are some of the reasons for this increase.

Table 8.10 shows the final figures for the 2002/03 season and the average figures of the last five seasons as well. The plantings of white maize in the 2002/2003 season were more or less on the same level as that of previous seasons.

Table 8.10: Regional area planted and production

Production season	**2002/03**		**AVE (97/98-2001/02)**		
Province	**HA**	**TON**	**T/HA**	**HA**	**TON**
W. Cape	3 0500	21300	6.96	1 385	8 812
N. Cape	53 800	514 320	9.69	29 240	275 860
Free State	1 055 000	2 893 000	2.90	1 048 400	2 895 900
Eastern Cape	12 000	53 800	4.05	10 480	38 200
KwaZulu-Natal	81 500	366 750	4.87	81 500	275 400
Mpumalanga	555 000	1 883 500	3.57	549 800	1 729 040
Limpopo	47 000	113 600	2.37	36 420	81 100
Gauteng	128 000	436 800	3.60	120 600	373 200
North West	1 080 000	2 561 000	2.57	1 048 600	2 311 500
Total RSA	**3 015 350**	**8 844 070**	**3.10**	**2 926 425**	**7 989 012**

During the 2002/2003 season the largest plantings took place in the Northwest Province, Free State in second place and Mpumalanga third. Production differs slightly with the largest crop in the Free State, Northwest second and Mpumalanga third.

It is also clear that although the Northern Cape does not feature in the top rankings as maize production region, yields are substantially higher since most of the maize is produced under irrigation.

Yield

Figure 8.27 shows the trend in average maize yield in South Africa. It is clear that the yield is in a definite growing trend. There are various factors that can influence yields and good cultivars, favourable growing conditions, timely planting is just a few.

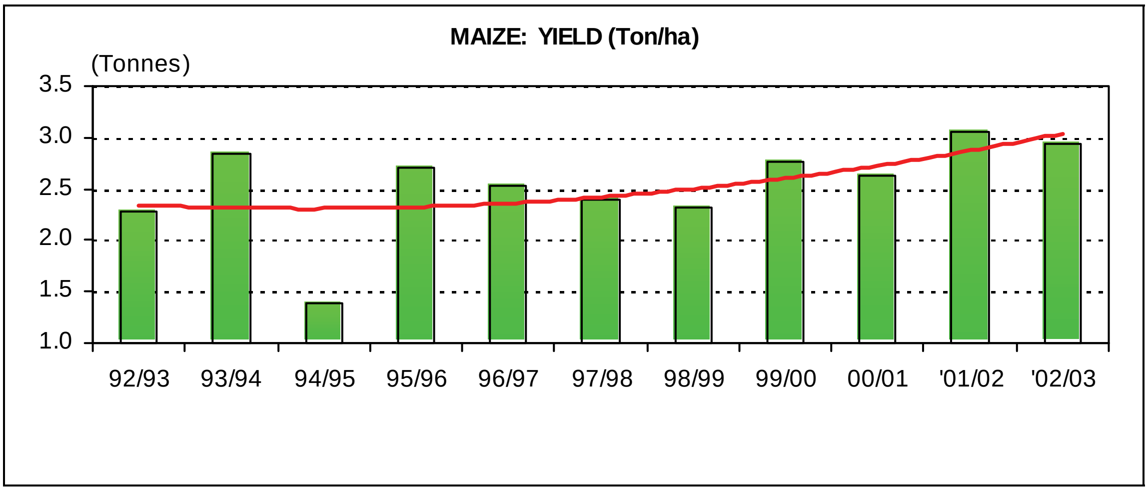


Figure 8.27: South African maize yield 1992/93-2002/03

The average yield of white maize for the period 92/93-96/97 were 2,49 tonnes per hectare but this figures increased to 2,67 tonnes per hectare in the next five year period (97/98- '01/02). The same happened with yellow maize as the average for the first mentioned period was 2,60 tonnes per hectare and increased in the next five-year period (97/98- '01/02) to 2,83 tonnes per hectare. The improvement can mainly be attributed to improved cultivars.

Consumption

Consumption/demand of maize for the period 97/98 to 2002/03 are discussed in this section. Figure 8.27 shows the consumption over this period. It is clear that the consumption of white and yellow maize to a lesser extent is in a growing trend. The recent drop in the white maize consumption this was caused by the relatively high price.

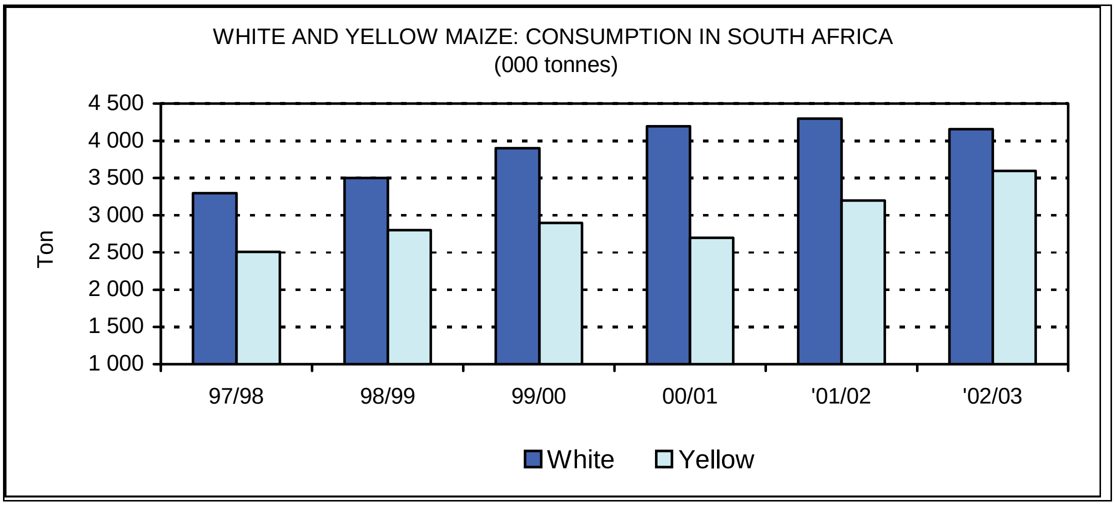


Figure 8.28: South African white and yellow maize consumption

Total commercial demand varies from season to season. The yellow maize demand reached a low in the 99/2000 season with a total consumption figure of only 3 232 million tonnes. Total consumption of yellow maize fluctuates between the 3 232 and 3 847 million ton. White maize demand is on a much higher level and consumption varies between 4 794 and 5 776 million ton. White maize, just like yellow maize, consumption declined in the 99/2000 seasons to a low of 4 747 million tonnes. The highest level was reached in the 2000/01 seasons with a total demand of 5 776 million tonnes. From time to time exports play an import role in the market. The export of maize (white and yellow) varied between 0 and 2 million ton over this period. The price of both white and yellow maize was very high during the largest part of the 2002/2003 season. The steep decrease in the prices lately is not going to influence the pattern either as the buyers and other users is waiting for the price to decrease further. It is expected that consumption figures for the food and feed market in the rest of this season and the new season (2003/04) will decline compared with consumption during the first part of the 2002/03 season – the reason for that is the high prices of the raw material. The current figures released by Grain South Africa (GSA) and South African Grain Information Services (SAGIS) show a declining trend as a result of the high prices of white and yellow maize. The most important factor to consider in the nearby future is the export figure, especially now that a large quantity is "discovered" in the domestic market. The situation in SADC countries is not good and South Africa is in a situation to assist.

Stocks

Ending stocks of maize during the 2003/2004 season is on a higher level than for the previous season. Also, it is believed that there are producers with relative large stocks which they carried over from the previous season.

Prices

Table 11 gives a summary of the current prices (March 2003) in the domestic and international market.

Table 8.11: Maize price outlook – March 23 2003

Item / Contract month	**Spot price** (2)	**Jul-03**	**Sep-03**
CBOT ($/ton)	89.76	89.92	90.31
SAFEX (R/ton):			
White	815	875	920
Yellow	899	911	957
Import price SA Randfontein (R/ton) (1)	1 047.75	1 100.69	1 126.68
Export price SA Randfontein (1)	668.,95	716.95	740.57
R/$ in calculations	8.04	8.5	8.7

1 *Import tariff R0,00.*
2 *USA Gulf harbour and Durban.*

The international price is currently (July 2003) on a much lower level than normal. The futures prices are telling that there is a good chance that prices could move sideways in coming months.

The rand strengthened substantially during the beginning of 2003 and this pushed import parity prices down. The import duty on maize was reduced on 4 October 2002 from R137.40 per ton to R43.60 per ton. In the meantime the tariff was adjusted downward again in November 2002 with the result that it is currently R0/ton. It was pointed out earlier that the international price trend is different from previous years and this is too a large extent true for the domestic situation as well. Figure 29 shows the weighted prices on JSE SAFEX of all maize contracts for white and yellow maize. The downward trend is clear.

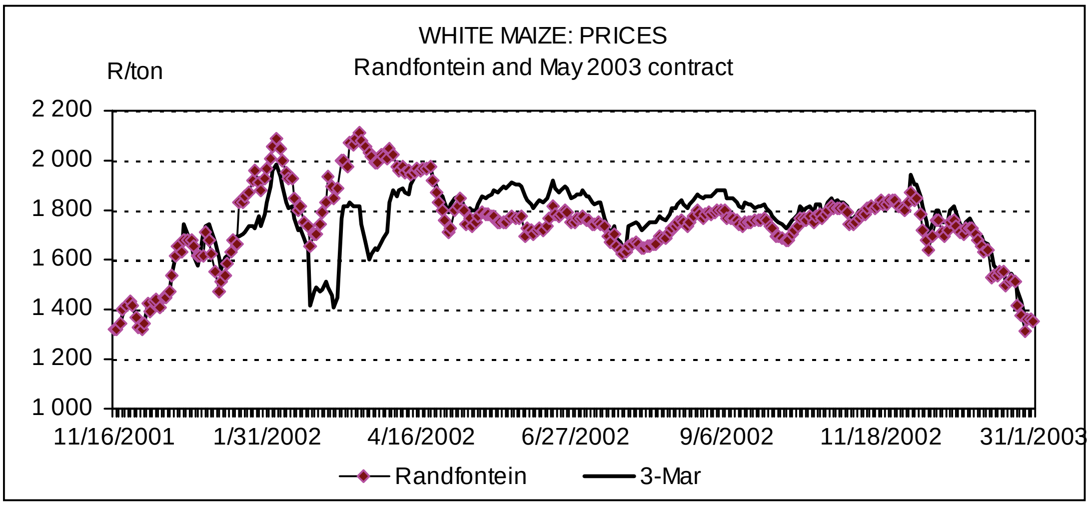


Figure 8.29: White maize SAFEX prices – May 2003

Figure 8.30 shows the US dollar price for yellow maize, as well as the Rand price in South African harbours, for either export or import purposes. The widening and closing of the gap between the US price and that of the imported/export parity price is clear.

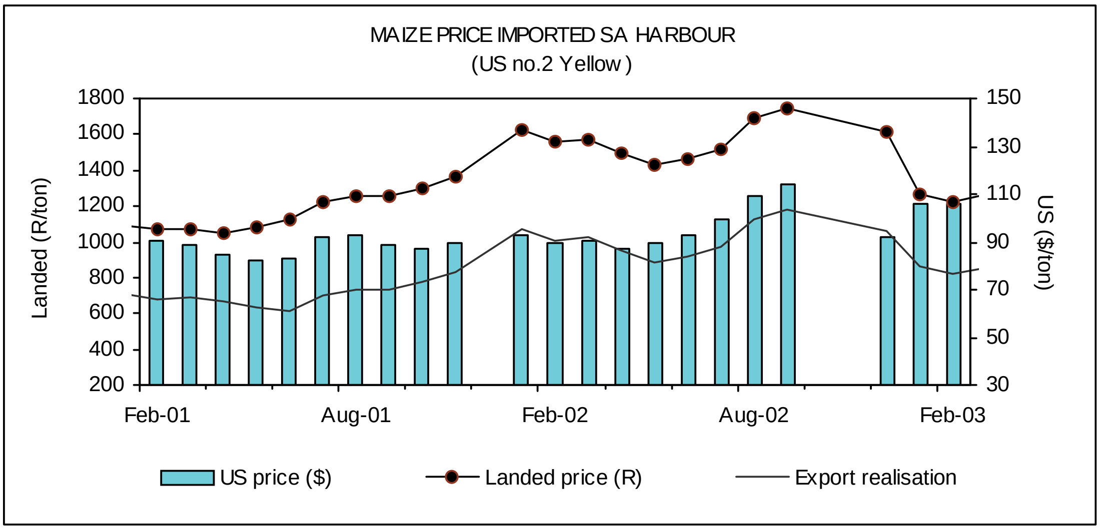


Figure 8.30: Imported maize price

It is not clear from Figure 30 that the price of maize usually drops during harvesting time in the US. The global coarse grain production curve usually reaches its peak during the middle of October and November of each year. Also, it is clear that the US$ price in the last couple of months is on a higher level than previous months.

Risk factors in maize production in South Africa

Although there are many potential risk factors in maize production under irrigation conditions. However, the following were identified as the most important:

- The exchange rate is important in the calculation of import parity and the strengthening of the rand is an important risk factor for local prices.
- Northern Hemisphere production impacts on international stock levels and therefore on the international price for maize.
- Local climatic conditions. For irrigated maize this will not necessarily be short-term drought periods but rather micro-climatic conditions as well as hail storms and flood conditions.

8.9.2 Wheat

8.9.2.1 International Supply

Table 8.12 shows the largest producers of wheat in the world for the marketing period 2001/02 (USDA, 2003). The EU is still the largest producer of wheat and the projected figure of 107.66 million tonnes is giving them a market share of just more than 18%. The second largest producer is China with a potential market share of 16.1%. Production in the US is much lower. However, they are the single most important country, affecting the world wheat situation throughout the world. Their potential market share is much lower (only 8%). Recent droughts in the USA, Canada and Australia have created a lot of pressure on world stocks. Northern Africa with potential imports of 16.00 million tonnes is currently the single largest importer of wheat.

Table 8.12: World production of wheat

Country	000 ton	Harvesting time
China	92 000	May-June
EU	107 660	June-August
United States	45 890	May-July
India	72 500	May-June
Other	254 720	-
World total	572 270	-

Table 8.13 shows the world supply and demand of wheat over three years. It is clear that ending stocks for the 2002/2003 season is approximately 30 million ton down from the 2000/2001 level of 168 million ton. Also, total consumption stayed relatively constant over this period while production decreased with approximately 10 million ton.

Table 8.13: World supply and demand of wheat.

World Wheat	2000/01 (Million ton)	2001/02 (Million ton)	2002/03 (Million ton)
Beginning stocks	175.40	168.66	161.34
Production	583.88	579.58	572.27
Imports	101.53	106.92	100.97
Exports	102.82	106.49	102.67
Feed consumption	105.14	107.86	107.82
Ending stocks	168.66	161.34	138.75
Total consumption	590.62	586.89	594.86

Source USDA (2003)

There is currently a constant drop in the production of wheat in the US and from the table above it is clear that the projected figure for the 2002/03-season is the lowest in many years and the fact that production dropped to these low levels is pushing ending stocks lower as well and this is affecting price to a large extent. This is also the case with China, the second largest producer. Their production dropped with ±10% when the current figure is compared with that of two years ago. In the EU, production is expected to increase to a higher level than that for the 2000/01-season.

Table 8.14: Wheat – USA supply and demand (million hectares and million ton)

Crop year	98/99	99/00	00/01	01/02	02/03
Harvested area	23.88	21.78	21.5	19.69	19.27
Yield	2.9	2.9	2.8	2.7	2.4
Beginning stocks	19.66	25.74	25.85	23.85	21.01
Production	69.33	62.57	60.76	53.28	45.89
Imports	2.8	2.57	2.45	2.93	2.86
Total supply	91.79	90.88	89.06	80.06	79.72
Exports	28.47	29.63	28.87	26.16	24.49
Domestic feed use	10.63	7.63	8.12	5.35	4.76
Domestic total use	37.58	35.41	36.34	32.88	32.55
Ending stocks	25.74	25.84	23.85	21.01	12.72

Source: USDA (2003)

Production of wheat in the Southern hemisphere is important to South Africa since these countries plant and market their product in basically the same time period as South Africa. In Argentine it is expected that farmers will scale down on wheat production in the short-run due to dry and cold conditions. Also, the planted area will likely be down as result of the high input costs, tight credit and economic uncertainty. Exacerbating the problem is the fact that Argentine farmers are retaining wheat as a form of currency. Australia is also important as they also market their product in the same time frame as local producers.

Demand

Projected world wheat consumption is slightly better than last month but much better than the figures of both previous years/seasons. The projected figure of 594,86 million ton for the 2002/03-season is the largest consumption figure ever. China is the largest consumer of wheat in the world and the projected consumption of 110 million ton is ±16 million ton more than its nearest competitor – the EU. The FSU is also large in terms of consumption with a consumption of 71.94 million tonnes. It is interesting to see that in the projections for the new season, consumption in the EU is ±87% of their own production. On the other hand, consumption in China is much higher than their own production with the result that they are in need of imports to secure enough stocks for their domestic market. The US market is the same as the other countries and their consumption is basically 50% of their production.

Brazil is currently searching global markets for wheat supplies as prices are skyrocketing in it's traditional supplier, Argentina. This situation is creating an opportunity for the United States, Canada and many non-traditional suppliers to increase their sales. Production in Brazil meets only about one third of the country's consumption needs.

The US is the largest exporter of wheat in the world with a projected nearly 25 million ton for the 2002/03-season. According to USDA (2003) Australia is the second largest exporter. Table 8.15 shows the USA's top 10 export markets. From a market analysis point of view it is important to monitor the economic/political situation in these countries since they will impact on international wheat prices.

Table 8.15: Top 10 USA export markets (ton)

	Oct-Jun 2001	Oct-Jun 2002	Jun-02
Egypt	2573630	2878330	176850
Japan	2346430	2384847	186564
Mexico	1480059	1642262	146436
Nigeria	1101639	1419156	178387
EU	724224	1044170	72403
Philippines	1435141	1013061	48534
South Korea	1063515	903078	66983
China	727390	703936	89488
Israel	425776	474844	64650
Yemen	384325	444510	69300
World	**18719656**	**18728897**	**1714161**

World stock, demand and supply

It is clear from Table 8.31 that ending stocks of wheat are down quite considerable as demand outperforms the production in many cases. The latest projection figures indicate a difference of ±22 million tonnes between production (572,27 million tonnes) and consumption (594,86 million tonnes). From Figure 8.31 it is clear that world wheat production in 2002/03 is expected to decline for the fifth consecutive year.

World wheat stocks during 2002/03 are expected to drop as mentioned above. It is expected that high prices will reduce world wheat trade to less than 103 million tonnes in 2002/03.

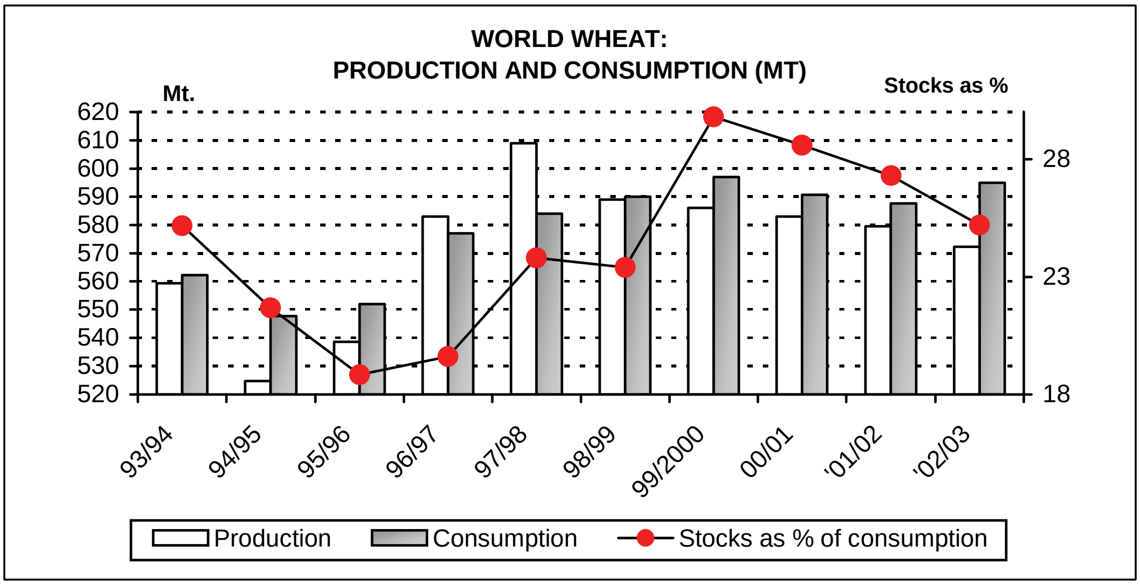


Figure 8.31: World production, consumption and stock trends
**Source: USDA (2003)*

Prices

Figure 8.32 shows the international wheat price from March 1998 up to February 2002. The all wheat average price received by farmers are currently on a much higher level than the two seasons before. The long-term (10-year average) of wheat is close to $150/ton. It is clear that the price of wheat is in a relative strong upward trend as result of the stock situation on the world market. The price of US hard red winter wheat increased quite dramatically in the last three months. Import parity is important as most sellers and buyers are measuring their prices against this price.

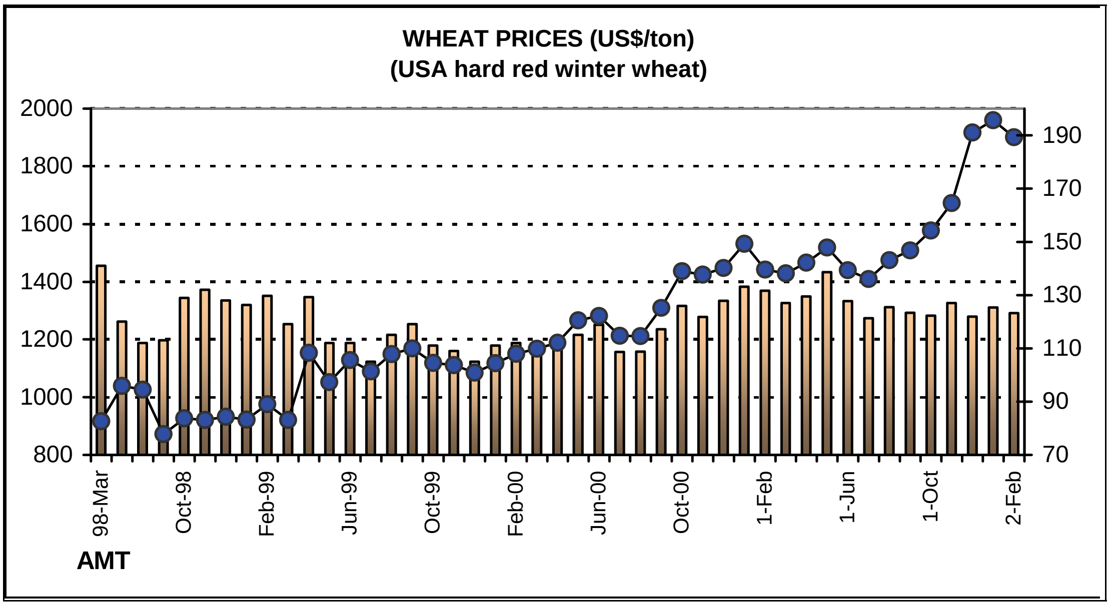


Figure 8.32: International wheat price

Import parity prices in SA are mostly affected by the Rand exchange rate against the Dollar. Domestic prices are "protected" from the record low international prices, by a variable import duty, based on an international price of USA $157/ton.

8.9.2.2 South Africa

Wheat is the second most important field crop in South Africa after maize. Wheat is important in the South African economy for the following reasons:

- Contribution to the total gross value of agricultural production
- It is the second most important staple food after maize
- There is no substitute for bread
- The wheat industry and its secondary industries create substantial employment opportunities on farms and related industries.

Production

Figure 8.33 shows the area and production of wheat in South Africa since 1992/93. The current plantings are more or less in line with that of the previous two seasons and basically on the same level as that of the five-year average.

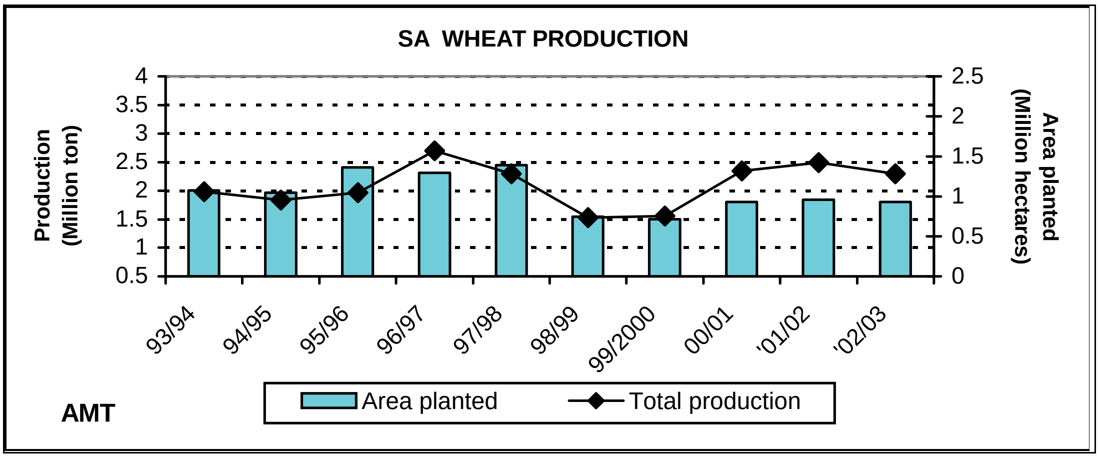


Figure 8.33: SA wheat production

Production fluctuates from year to year as result of the conditions during seasons and the area planted. For many years local production was adequate to supply the local industry to a great extent but in the last few seasons is wasn't adequate and imports were necessary to supplement supplies to the domestic market.

Quality became very important lately and the falling method of grading caused a lot of problems in the local industry with the result that millers and bakers looked at alternatives. Table 8.16 shows the final production figures for 2001/2002.

Table 8.16: NCEC's final production figures for the 2001/02

	Area planted 2001/02 (ha)	Area planted 2002/03 (ha)	Production 2001/02 ton	Production 2002/03 ton
West Cape	374 000	380 000	691 000	874 000-
Northern Region	585 400	555 100	1 657 550	1 424 100
Total:	959 400	935 100	2 348 550	2 298 100

Source: AMT (2003)

The production of wheat has moved to irrigation areas in the northern regions (this includes parts of the Northern Cape), while only high potential soil stayed in production in the Western Cape. It is therefore obvious that the average yield per ha will increase in future. Figure 34 shows the shift in wheat production. It is clear that after a steep decline in production in the rest of the country (compared to the Western Cape) during 1997/1998, production started to steadily increase again during the 1999/2000.

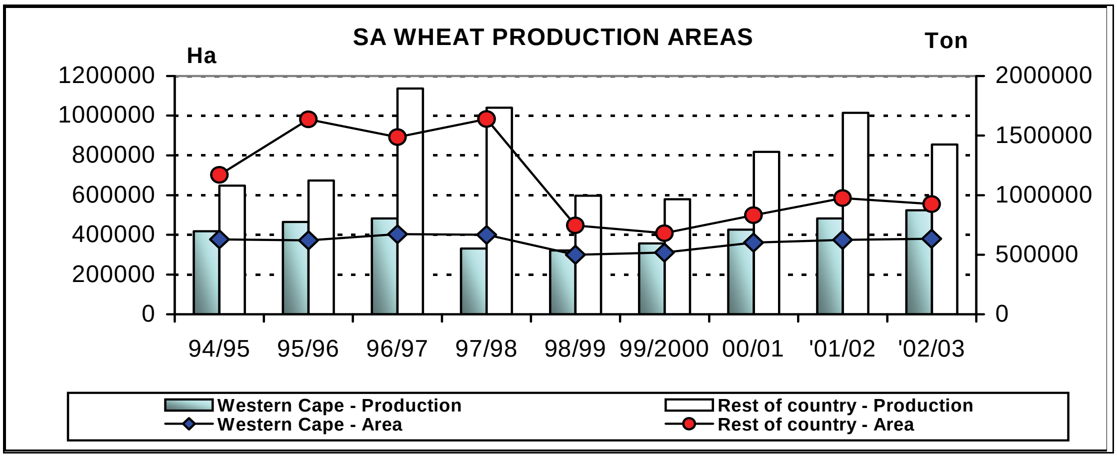


Figure 8.34: SA wheat production areas

It is clear from Figure 8.34 that the area planted is currently in a sideways trend. It is also clear that the area planted with wheat in the Western Cape is basically on the same level as previous years. Production in the rest of the country is on a much lower level than that of the 94/95-97/98 seasons. Table 8.17 shows the area planted and also the first production estimates for the 2002/03 season.

Table 8.17: Area planted and production estimate for 2002/2003

PROVINCE	AREA PLANTED	FIRST ESTIMATE
WESTERN CAPE	380 000	874 000
NORTHERN CAPE	50 000	280 000
FREE STATE	427 000	789 950
EASTERN CAPE	3 500	8 750
KWAZULU-NATAL	8 600	43 000
MPUMALANGA	22 000	112 200
LIMPOPO	13 500	40 500
GAUTENG	2 500	12 500
NORTH-WEST	28 000	137 200
TOTAL	935 100	2 298 100

Source: AMT (2003)

In terms of the area planted, the Free State remains the most important production region followed by the Western Cape. However, it is also important to consider the production which is a function of yield and area. It is interesting to note that the Northern Cape with a area of only 50 000 ha (mainly irrigation) produces approximately 280 000 ton whereas

Stocks, supply and demand conditions

Table 8.18 shows an example of a domestic wheat balance. It is important that farmers consider the stock situation when they do their annual production planning. If carryover stocks are high one can expect that there will be downward pressure on prices in the next season.

Table 8.18: Example of domestic wheat balance

DOMESTIC WHEAT BALANCE SHEET FOR THE 1999/2000 TO 2001/2002 SEASONS			
	2000/2001	**2001/2002**	**2002/2003**
Carry-over stock (1 Oct)	507 000	551 000	485 882
Plus: Commercial producers crop	2 348 550	2 492 880	2 298 000
Total domestic supply	2 855 550	3 043 880	2 783 882
Plus: Imports	290 636	180 000	0
Commercial available	3 146 186	3 223 880	2 783 882
Minus: Commercial use	2 346 273	2 501 455	2 423 864
Minus: Feed use	23 500	15 000	19 250
Minus: Working stocks (3 weeks)	136 718	145 180	140 949
Available for export or farmer /trader storage	639 696	562 245	199 819
Minus exports	88 500	76 364	150 000
Ending stocks	551 196	485 882	49 819

Source: AMT (2003)

Table 8.18 clearly shows that the fact that production during the 2001/2002 season was lower than the previous season together with smaller carry-over stocks reduced total supply in the 2002/2003 season compared to that of the previous two seasons. Also, problems with shortages of wheat in the world could easily lead to no imports and that will create shortages in the domestic market as well. Consumption of wheat in South Africa remains more or less constant at ±2,5 million ton.

Most producers adapted to a large extent to the current grading regulations and the falling method of wheat grading is no longer the big monster of previous seasons.

Local market and price determinants

Figure 8.35 shows the international USA wheat price in dollar / ton and the South African import parity price at the harbour, taking into account the import duty, as well as the export price at the harbour. Domestic transport costs are excluded.

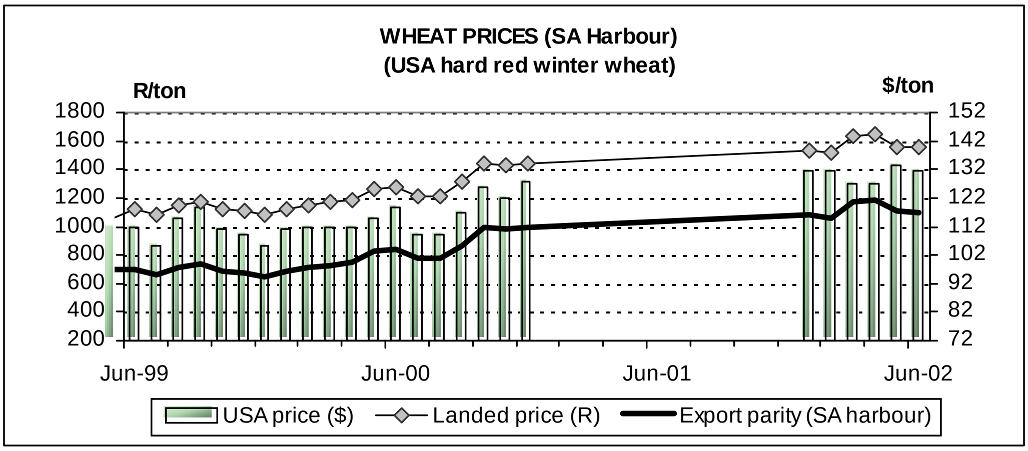


Figure 8.35: South African wheat prices
Source: AMT (2003)

International prices continue to move high and the tight world stock situation is not going to disappear in one or two seasons and prices are going to stay firm. This will also be for commodities like soybeans and maize. The high international prices of all three commodities are going to influence the prices in the domestic market as well. However the Rand/Dollar exchange will determine price levels in South Africa. At the writing of this report the rate was round about R7.80 to the Dollar. The strong Rand induced tremendous pressure on the local price for wheat. It is not expected that the Rand will strengthen much more and the general feeling is that Rand is close to its turning point. It is expected that the Rand will slowly start to devaluate against the Dollar during the second half of 2003. Another factor to consider is the import tariff for wheat which the Government adapt from time to time as circumstances change.

The producer price of wheat is a derived price from SAFEX and it differs from location to location. It seems to be that producers have adapted to the new marketing environment after deregulation and they are much more aware of the marketing conditions locally and internationally. When prices are low they tend to hold back their product in anticipation of a higher price.

8.9.3 Conclusion

The risk factors involved in wheat production is to a large extent identical to those for maize. They are:

- The exchange rate is important in the calculation of import parity and the strengthening of the rand is an important risk factor for local prices.
- Northern Hemisphere production impacts on international stock levels and therefore on the international price for wheat.
- Local climatic conditions. For irrigated wheat this will not necessarily be short-term drought periods but rather micro-climatic conditions as well as hail storms and flood conditions.
- Hikes in input costs. Although the recent strengthening of the Rand are suppose to lead to a decrease in input costs, producers are of the opinion that input prices do not decline in relation to the strengthening of the Rand.

8.10 ESTIMATING DIRECT PRODUCTION COSTS

Since many of the identified crops are not common in South Africa it is very difficult to find production costs estimates for these crops. It was therefore necessary to use international information obtained from various sources on the internet and to convert these budgets to local currency. The reader should be aware that it is possible that there may be variations due to differences in especially labour costs and possibly also other inputs. However, in the absence of local information it is assumed that these budgets will at least give an indication of the costs relatively to the production of other crops. Also, where local price information could not be obtained it was assumed that the international price quoted on various internet sites will also apply in South Africa. This assumption is not as farfetched as it may seem since after deregulation South African agriculture operates in a relative free market environment where price are determined in the international markets.

Table 8.19: Vegetable gross margin estimate excluding water costs

Crop	Total	Yield	Yield	Price	Gross	Gross	Water use	GM	Source
	DAC	unit		/ unit	income	margin(GM)	m3/ha	per m3	
Beetroot	23255	Ton	28	1255	35140	11885	5800	2.05	DAWC
Greenbeans	27546	Ton	15	2767	41505	13959	3220	4.33	DAWC
Broccoli	21555	Ton	8	3490	27920	6365	2370	2.69	DAWC
Brussels	27453	ton	9	5184	46656	19203	2370	8.10	DAWC
Cabbage	27875	Ton	65	610	39650	11775	7000	1.68	DAWC
Carrots	41814	Ton	70	1300	91000	49186	5800	8.48	DAWC
Cauliflower	13502	Ton	15	1170	17550	4048	5800	0.70	DAWC
Celery	55976	Ton	10	7170	71700	15724	5800	2.71	ADAC
Clobe artichokes	37146	kg	6300	8.0	50381	13235	5800	2.28	University of California
Horseradish	0			15000	0	0	5800	0.00	Not available
Lettuce	26685	Each	25000	1.3	32500	5815	5800	1.00	DAWC
Morog	0				0	0	5800	0.00	Not available
Onions	47168	Each	5500	15	82500	35332	5260	6.72	DAWC
Peas	21015	Ton	12	5850	70200	49185	3150	15.61	DAWC
Radish				2916	0	0	5800	0.00	No cost estimate
Salsify					0	0	5800	0.00	No info
Spinach	14060	ton	10	1877	18770	4710	5800	0.81	DAWC
Turnips	10638	ton	12	1368	16416	5778	5800	1.00	Mississipi State University
Potatoes	42500	Bag	3800	15	57000	14500	3090	4.69	GWK

Table 8.20: Field crop gross margin estimate excluding water costs

Crop	Total	Yield	Yield	Price	Gross	Gross	Water use	GM	Source
	DAc	unit		/unit	income	margin	m3/ha	per m3	
Lentil									No information
Lucerne establish	5931	Bales	320	20	6400	469	7200	0.07	DAWC
Lucerne y2-3	6323	Bales	720	20	14400	8077	7200	1.12	DAWC
Lucerne y4-6	5333	Bales	480	20	9600	4267	7200	0.59	DAWC
Wheat	7053	Ton	6.5	1700	11050	3997	4970	0.80	GWK
Maize	6874	Ton	8	1200	9600	2726	3670	0.74	GWK

Table 8.21: Long-term crop gross margin estimates excluding water costs

Crop	Direct costs	Yield unit	Yield	Price	Gross income	Gross margin	Water m3/ha	GM per m3	Source
Asparagus est	-13827					-13827	2150	-6.4	Univ. California
Asparagus y2	-5867	ton	0.45	13200	5940	72.927	2150	0.0	Univ. California
Asparagus y3	-8334	ton	1	13200	13200	4865.8	2150	2.3	Univ. California
Asparagus y4	-8927	ton	1.5	13200	19800	10873	2150	5.1	Univ. California
Asparagus y5+	-10713	ton	2	13200	26400	15687	2150	7.3	Univ. California
Tablegrape est.	-100736				0	-100736	1100	-91.6	DAWC
Tablegrape y1-2	-6176				0	-6176	1100	-5.6	DAWC
Tablegrapes y3-4	-45957	4.5kg	2000	50	100000	54043	1100	49.1	DAWC
Tablegrapes y5+	-71052	4.5kg	3000	50	150000	78948	1100	71.8	DAWC
Plum est	-87754				0	-87754	4160	-21.1	DAWC
Plums y2	-13989				0	-13989	4160	-3.4	DAWC
Plums 3-4	-42970	5kg	2000	35	70000	27030	4160	6.5	DAWC
Plums y5+	-67731	5kg	3000	35	105000	37269	4160	9.0	DAWC
Peaches est.	-96530				0	-96530	4160	-23.2	DAWC
Peaches y2	-15388				0	-15388	4160	-3.7	DAWC
Peaches y3-4	-47267	2.5kg	2400	30	72000	24733	4160	5.9	DAWC
PeachesY5+	-74504	2.5kg	3600	30	108000	33496	4160	8.1	DAWC
Raspberries est	-4272	kg	0	11.5	0	-4272	4800	-0.9	Alberta Agric
Raspberries y1	-20167	kg	0	11.5	0	-20167	4800	-4.2	Alberta Agric
Raspberries y2	-18210	kg	2000	11.5	23000	4790	4800	1.0	Alberta Agric
Raspberries y3	-14103	kg	3000	11.5	34500	20397	4800	4.2	Alberta Agric
Raspberries y4	-14567	kg	4000	11.5	46000	31433	4800	6.5	Alberta Agric
Strawberries est	-7354	kg	0	7.5	0	-7354	4800	-1.5	Univ. California
Strawberries y1	-34000	kg	4500	8	36000	2000	4800	0.4	Univ. California
Strawberries y2	-36698	kg	9000	8	72000	35302	4800	7.4	Univ. California
Strawberries y3	-37711	kg	7500	8	60000	22289	4800	4.6	Univ. California
Cranberries est	-137209	Box			0	-137209	4800	-28.6	Univ. California
Cranberries y2	-25698	Box			0	-25698	4800	-5.4	Univ. California
Cranberries y3-5	-39427	Box	220	430	94600	55173	4800	11.5	Univ. California
Cranberries y6-20	-40756	Box	320	430	137600	96844	4800	20.2	Univ. California
Rhubarb est	-78244	kg			0	-78244	4800	-16.3	Prince Edw Agric
Rhubarb y1	-4056	kg			0	-4056	4800	-0.8	Prince Edw Agric
Rhubarb y2	-24076	kg	17500	6.976	122080	98004	4800	20.4	Prince Edw Agric
Rhubarb y3	-29796	kg	22500	6.976	156960	127164	4800	26.5	Prince Edw Agric
Rhubarb y4-15	-35516	kg	27500	6.976	191840	156324	4160	37.6	Prince Edw Agric

Table 8.22: Herb gross margin estimates excluding water costs

Crop	Total DAC	Yield unit	Yield	Price / unit	Gross income	Gross margin	Water use m3/ha	GM per m3	Source
Culinary herbs	1751641	kg	42524	48.1	2047500	295859	2400	123.3	Greenhouse
Collard					0	0	2400	0.0	Not available
Dill	3157	kg	1100	5.7	6303	3146	2400	1.3	Alberta Agric
Camomile					0	0	2400	0.0	Not available
Corn mint					0	0	2400	0.0	Not available
Dandelion	4265	kg	500	57.3	28660	24395	2400	10.2	Alberta Agric
Endive		kg		2.5	0	0	2400	0.0	Alberta Agric
Fennel		kg		5.0	0	0	2400	0.0	Not available
Garlic	9658	kg	1600	9.6	15328	5670	2400	2.4	Alberta Agric
Parsley		kg	320	4.4	1401	1401	2400	0.6	Alberta Agric
Peppermint	4080	kg	35	172.0	6019	1939	2400	0.8	Alberta Agric
Pirethrum					0	0	2400	0.0	Not available

Table 8.23: Flower gross margin estimates excluding water costs

Crop	Total DAC	Yield unit	Yield	Price / unit	Gross income	Gross margin	Water use m3/ha	GM per m3	Source
Cutflowers mix		ton		21905	0				Not available
Flower bulbs	-616560	Bulbs	480000	1.5	720000	103440	1160	89.172	OABS

8.11 WATER PURIFICATION SCENARIOS

Table 23 shows the impact yield at different water qualities for the identified crops. It is clear that at a level of 40 mS/m there is no yield reduction on both soil types. When water is only purified to 100 mS/m yield reduction is minimal on the sandy soils. However, Beans, Brussels sprouts, Carrots, Cauliflower, Lettuce, Onions, Peas, Pumpkin, Strawberries, Garlic and Perennial fruits all show a yield reduction of more than 9 percent.

Table 8.24: Sensitivity of crops to soil salinity induced by two different water qualities on a sandy and clay soil

Common Name	**Sandy soil**		**Clay soil**	
Vegetable Crops	Water =100 mS/m	Water = 40 mS/m	Water =100 mS/m	Water = 40 mS/m
Asparagus	No loss	No loss	No loss	No loss
Beans	3.8 %	No loss	22.8 %	No loss
Beetroot	No loss	No loss	No loss	No loss
Broccoli	No loss	No loss	No loss	No loss
Brussels sprouts	No loss	No loss	9.1 %	No loss
Cabbage	No loss	No loss	3.9 %	No loss
Carrot	2.8 %	No loss	16.8 %	No loss
Cauliflower	No loss	No loss	9.1 %	No loss
Celery	No loss	No loss	3.8 %	No loss
Chard	No loss	No loss	No loss	No loss
Lettuce	No loss	No loss	11.7 %	No loss
Morog (African spinach)	No loss	No loss	No loss	No loss
Onion	No loss	No loss	16.0 %	No loss
Pea	3.2 %	No loss	19.2 %	No loss
Pumpkin	No loss	No loss	9.1 %	No loss
Spinach	No loss	No loss	1.52 %	No loss
Strawberry	6.6 %	No loss	39.6 %	No loss
Herbs, medical, spices				
Garlic	No loss	No loss	(16 %)	No loss
Parsley	No loss	No loss	No loss	No loss
Peppermint	No loss	No loss	No loss	No loss
Perennial fruit, nut crop				
Apricot	No loss	No loss	14.4 %	No loss
Black currant	3.2 %	No loss	19.2 %	No loss
Cranberry	No loss	No loss	(15. %)	No loss
Dewberry	No loss	No loss	15.4 %	No loss
Grape	No loss	No loss	6.72 %	No loss

Common Name	Sandy soil		Clay soil	
Peach	No loss	No loss	10.5 %	No loss
Plum	No loss	No loss	(14 %)	No loss
Field crops				
Lucerne	No loss	No loss	1.4 %	No loss
Maize	No loss	No loss	6 %	No loss
Potato	No loss	No loss	6 %	No loss
Flower crops				
Azalea	No loss	No loss	(2 %)	No loss
Carnation	No loss	No loss	(2 %)	No loss
Chrysanthemum	No loss	No loss	(No loss)	No loss
Gardenia	No loss	No loss	(2 %)	No loss
Geranium	No loss	No loss	(2 %)	No loss
Lily	No loss	No loss	(2 %)	No loss
Poinsettia	No loss	No loss	(No loss)	No loss
Roses	No loss	No loss	2.2 %	No loss

Gross margins at a water quality of 40 ms/m costing R3.40 per m^3

Only the crops for where cost estimates are available were considered in this analysis. As expected only the high valued crops can be cultivated profitable when water cost R3.40 per m^3. These crops include herbs, flower bulb, fruit and some of the vegetables.

Table 8.25 Prioritisation of crop profitability at 40 mS/m

Crop	Total DAC	Yield unit	Yield	Price / unit	Gross income	Gross margin	Water req m3	Water cost	GM include water cost	GM per m3
Culinary herbs	1751641	kg	42524	48.1	2047500	295859	2400	8160	287699	35.26
Flower bulbs	616560	Bulbs	480000	1.5	720000	103440	1160	3944	99496	25.23
Table grapes y5+	71052	4.5kg	3000	50	150000	78948	1100	3740	75208	20.11
Rhubarb y4-15	35516	kg	27500	6.976	191840	156324	4160	14144	142180	10.05
Cranberries y6-20	40756	Box	320	430	137600	96844	4800	16320	80524	4.93
Peas	21015	Ton	12	5850	70200	49185	3150	10710	38475	3.59
Dandelion	4265	kg	500	57.3	28660	24395	2400	8160	16235	1.99
Plums y5+	67731	5kg	3000	35	105000	37269	4160	14144	23125	1.63
Carrots	41814	Ton	70	1300	91000	49186	5800	19720	29466	1.49
Brussels	27453	ton	9	5184	46656	19203	2370	8058	11145	1.38
PeachesY5+	30198	2.5kg	3600	30	108000	77802	4160	14144	63658	4.50
Strawberries y2	36698	kg	9000	8	72000	35302	4800	16320	18982	1.16
Asparagus y5+	10713	ton	2	13200	26400	15687	2150	7310	8377	1.15
Onions	47168	Each	5500	15	82500	35332	5260	17884	17448	0.98
Raspberries y4	14567	kg	4000	11.5	46000	31433	4800	16320	15113	0.93
Potatoes	42500	Bag	3800	15	57000	14500	3090	10506	3994	0.38
Greenbeans	27546	Ton	15	2767	41505	13959	3220	10948	3011	0.27
Celery	55976	Ton	10	7170	71700	15724	5800	19720	-3996	-0.20
Broccoli	21555	Ton	8	3490	27920	6365	2370	8058	-1693	-0.21
Garlic	9658	kg	1600	9.6	15328	5670	2400	8160	-2490	-0.31
Globe artichokes	37146	kg	6300	8.0	50381.1	13235	5800	19720	-6485	-0.33

Crop	Total DAC	Yield unit	Yield	Price / unit	Gross income	Gross margin	Water req m3	Water cost	GM include water cost	GM per m3
Beetroot	23255	Ton	28	1255	35140	11885	5800	19720	-7835	-0.40
Cabbage	27875	Ton	65	610	39650	11775	7000	23800	-12025	-0.51
Dill	3157	kg	1100	5.7	6303	3146	2400	8160	-5014	-0.61
Lucerne y2-3	6323	Bales	720	20	14400	8077	7200	24480	-16403	-0.67
Lettuce	26685	Each	25000	1.3	32500	5815	5800	19720	-13905	-0.71
Turnips	10638	ton	12	1368	16416	5778	5800	19720	-13942	-0.71
Spinach	14060	ton	10	1877	18770	4710	5800	19720	-15010	-0.76
Peppermint	4080	kg	35	172.0	6019	1939	2400	8160	-6221	-0.76
Wheat	7053	Ton	6.5	1700	11050	3997	4970	16898	-12901	-0.76
Maize	6874	Ton	8	1200	9600	2726	3670	12478	-9752	-0.78
Cauliflower	13502	Ton	15	1170	17550	4048	5800	19720	-15672	-0.79
Lucerne y4-6	5333	Bales	480	20	9600	4267	7200	24480	-20213	-0.83

Gross margins at a water quality of 100 ms/m costing R2.10 per m^3

Sand soils

In the following analysis, crop yields were reduced according to the estimates made by Nel (2003) and the water cost reduced to R2.10 per m^3. Table 26 shows that many crops, especially some of the vegetables, grain and lucerne cannot be produced profitable.

Table 8.26: Gross margins on sandy soils at 100 mS/m and R2.10 per m^3

No.	Crop	Total DAC	Yield unit	Yield	Price / unit	Gross income	Gross margin	Water req m^3	Water cost	GM include water cost	GM per m^3
1	Culinary herbs	1751641	kg	42524	48.1	2047500	295859	2400	5040	290819	57.70
2	Flower bulbs	616560	Bulbs	480000	1.5	720000	103440	1160	2436	101004	41.46
3	Table grapes y5+	71052	4.5kg	3000	50	150000	78948	1100	2310	76638	33.18
4	Rhubarb y4-15	35516	kg	27500	6.976	191840	156324	4160	8736	147588	16.89
5	Cranberries y6-20	40756	Box	320	430	137600	96844	4800	10080	86764	8.61
6	PeachesY5+	30198	2.5kg	3600	30	108000	77802	4160	8736	69066	7.91
7	Peas	21015	Ton	12	5850	70200	49185	3150	6615	42570	6.44
8	Dandelion	4265	kg	500	57.3	28660	24395	2400	5040	19355	3.84
9	Plums y5+	67731	5kg	3000	35	105000	37269	4160	8736	28533	3.27
10	Carrots	41814	Ton	70	1300	91000	49186	5800	12180	37006	3.04
11	Brussels	27453	ton	9	5184	46656	19203	2370	4977	14226	2.86
12	Strawberries y2	36698	kg	9000	8	72000	35302	4800	10080	25222	2.50
13	Asparagus y5+	10713	ton	2	13200	26400	15687	2150	4515	11172	2.47
14	Onions	47168	Each	5500	15	82500	35332	5260	11046	24286	2.20
15	Raspberries y4	14567	kg	4000	11.5	46000	31433	4800	10080	21353	2.12
16	Potatoes	42500	Bag	3800	15	57000	14500	3090	6489	8011	1.23
17	Greenbeans	27546	Ton	15	2767	41505	13959	3220	6762	7197	1.06
18	Celery	55976	Ton	10	7170	71700	15724	5800	12180	3544	0.29
19	Broccoli	21555	Ton	8	3490	27920	6365	2370	4977	1388	0.28

No.	Crop	Total DAC	Yield unit	Yield	Price / unit	Gross income	Gross margin	Water req m^3	Water cost	GM include water cost	GM per m^3
20	Garlic	9658	kg	1600	9.6	15328	5670	2400	5040	630	0.13
21	Globe artichokes	37146	kg	6300	8.0	50381.1	13235	5800	12180	1055	0.09
22	Beetroot	23255	Ton	28	1255	35140	11885	5800	12180	-295	-0.02
23	Cabbage	27875	Ton	65	610	39650	11775	7000	14700	-2925	-0.20
24	Dill	3157	kg	1100	5.7	6303	3146	2400	5040	-1894	-0.38
25	Lucerne y2-3	6323	Bales	720	20	14400	8077	7200	15120	-7043	-0.47
26	Lettuce	26685	Each	25000	1.3	32500	5815	5800	12180	-6365	-0.52
27	Turnips	10638	ton	12	1368	16416	5778	5800	12180	-6402	-0.53
28	Spinach	14060	ton	10	1877	18770	4710	5800	12180	-7470	-0.61
29	Peppermint	4080	kg	35	172.0	6019	1939	2400	5040	-3101	-0.62
30	Wheat	7053	Ton	6.5	1700	11050	3997	4970	10437	-6440	-0.62
31	Maize	6874	Ton	8	1200	9600	2726	3670	7707	-4981	-0.65
32	Cauliflower	13502	Ton	15	1170	17550	4048	5800	12180	-8132	-0.67
33	Lucerne y4-6	5333	Bales	480	20	9600	4267	7200	15120	-10853	-0.72

Clay soils

The impact of a reduced yield at 100 mS/m on clay soils and the resulting reduction in gross margin is presented in table 27. It is clear that the top 8 crops in terms of gross margin stay in the same position. However, small changes take place, e.g. Asparagus moves from 13th to 9th, Carrots from 10th to 11th, and Plums from 9th to 12th.

Table 8.27: Gross margins on clay soils at 100 mS/m and R2.10 per m^3

No.	Crop	Total DAC	Yield unit	Yield	Price / unit	Gross income	Gross margin	Water req m3	Water cost	GM include water cost	GM per m3
1	Culinary herbs	1751641	kg	42524	48.1	2047500	295859	2400	5040	290819	57.70
2	Flower bulbs	616560	Bulbs	470400	1.5	705600	89040	1160	2436	86604	35.55
3	Table grapes y5+	71052	4.5kg	2850	50	142500	71448	1100	2310	69138	29.93
4	Rhubarb y4-15	35516	kg	27500	6.976	191840	156324	4160	8736	147588	16.89
5	Cranberries y6-20	40756	Box	272	430	116960	76204	4800	10080	66124	6.56
6	PeachesY5+	39068	2.5kg	3240	30	97200	58132	4160	8736	49396	5.65
7	Peas	21015	Ton	9.6	5850	56160	35145	3150	6615	28530	4.31
8	Dandelion	4265	kg	500	57.3	28660	24395	2400	5040	19355	3.84
9	Asparagus y5+	10713	ton	2	13200	26400	15687	2150	4515	11172	2.47
10	Brussels	27453	ton	8.1	5184	41990.4	14537	2370	4977	9560	1.92
11	Carrots	41814	Ton	58.1	1300	75530	33716	5800	12180	21536	1.77
12	Plums y5+	67731	5kg	2550	35	89250	21519	4160	8736	12783	1.46
13	Raspberries y4	14567	kg	3400	11.5	39100	24533	4800	10080	14453	1.43
14	Potatoes	42500	Bag	3800	15	57000	14500	3090	6489	8011	1.23
15	Onions	47168	Each	4620	15	69300	22132	5260	11046	11086	1.00
16	Broccoli	21555	Ton	8	3490	27920	6365	2370	4977	1388	0.28
17	Globe artichokes	37146	kg	6300	8.0	50381.1	13235	5800	12180	1055	0.09
18	Celery	55976	Ton	9.6	7170	68832	12856	5800	12180	676	0.06
19	Beetroot	23255	Ton	28	1255	35140	11885	5800	12180	-295	-0.02
20	Greenbeans	27546	Ton	11.7	2767	32373.9	4827	3220	6762	-1935	-0.29

21	Cabbage	27875	Ton	62.4	610	38064	10189	7000	14700	-4511	-0.31
22	Strawberries y2	36698	kg	5400	8	43200	6502	4800	10080	-3578	-0.35
23	Garlic	9658	kg	1344	9.6	12876	3218	2400	5040	-1822	-0.36
24	Dill	3157	kg	1100	5.7	6303	3146	2400	5040	-1894	-0.38
25	Lucerne y2-3	6323	Bales	720	20	14400	8077	7200	15120	-7043	-0.47
26	Turnips	10638	ton	12	1368	16416	5778	5800	12180	-6402	-0.53
27	Spinach	14060	ton	10	1877	18770	4710	5800	12180	-7470	-0.61
28	Peppermint	4080	kg	35	172.0	6019	1939	2400	5040	-3101	-0.62
29	Wheat	7053	Ton	6.11	1700	10387	3334	4970	10437	-7103	-0.68
30	Lucerne y4-6	5333	Bales	480	20	9600	4267	7200	15120	-10853	-0.72
31	Maize	6874	Ton	7.52	1200	9024	2150	3670	7707	-5557	-0.72
32	Cauliflower	13502	Ton	13.5	1170	15795	2293	5800	12180	-9887	-0.81
33	Lettuce	26685	Each	22250	1.3	28925	2240	5800	12180	-9940	-0.82

8.12 DETAILED CASE STUDY – 10 Mℓ PER DAY PLANT

To give the reader an indication of what the return on capital investment may be a 10 mega liter purifying plant were used as case study.

Assumptions

Since there are still many uncertainties it was necessary to make assumptions. However, most of these assumptions are based on comparison with the observed cost structure of similar farms. The following assumptions were made:

Table 8.28: Assumption for the 10 Mℓ plant case study

Assumptions	**Unit**	**Value**
Water delivering capacity at farm border (50% of delivery at purify plant)	m3/annum	1 825 000
Cost of purification for 10 Ml/day plant (100 mS)	Rand/m^3	2.1
Agricultural land required to utilise water	ha	5,15
Capital cost of purification plant up to farm border	Rand	40 000 000
Capital on-farm investment required (based on similar farm structure)		
Land plus initial land preparation (R1500 plus R25 000)	ha	26 500
Fixed improvements (packing and other sheds, housing, pump houses, etc.)	ha	25 627
Machinery, implements and equipment	ha	8 870
Total capital investment per 550 ha	515 ha	31 413 455
Payback of capital over 15 years at 14% interest	Rand	11 626 825
Labour assumptions (based on experience on similar farm structure)		
Potential new permanent equivalent* job opportunities	ha	1.1
Other overhead expenditures (electricity, consultants, tax, general farm, etc.)	515 ha	3 347 500

* Permanent equivalent labourer = based on the number of working hours for a permanent labourer
This includes casual and permanent labour hours

In the absence of an optimization model (e.g. linear programming), it was not possible to optimize the crop combination. However, the crops were selected on the basis of the analysis in section 9 and it was assumed that for the purpose of this report the combination will give an indication of the return on capital investment that may be expected. However, the reader should be aware that in the case of perennial crops full bearing/full grown plants were included in the analysis. In many cases perennial crops takes two to four years before they are in full production. In some cases it is also necessary to re-establish these crops during the planning horizon. The following analysis is therefore a snapshot in a future cash flow based on present technology and present price information. In a full cost-benefit analysis the return on capital investment will definitely be lower than the one calculating in this case study (probably in the order of 2 to 3 percent). Also, the proper methodology to be used in such a study will be Net Present Value methodology.

In spite of all the assumptions the author is confident that the analysis in this report gives valuable insight into the planning problem and will assist decision makers to make meaningful decisions at this stage of the feasibility study.

Results

Table 8.29 and 8.30 is a summary of key information which was calculated from the analysis in Table 8.31. The high cost of the water necessitates the cultivation of high value crops such an herbs, stone fruit, and berries. The area under herbs and flowers are limited due to market consideration. The reader must be aware that the area contribution indicated in Table 8.29 will not necessary be exactly the same in the final planning stage since there are many other (physical/managerial) factors that may impact on a final selection. The planning problem centers on the selection of high value high water consumption high salt tolerance crops.

Table 8.29: % Contribution to total area

Crop	**Area contribution (%)**
Herbs	14.6%
Flowers	4.9%
Stone fruit	9.7%
Vegetables	58.3%
Berries	12.6%
Total	100.0%

Table 30 indicates that the selected crop combination will use 99.6% of the available water (considering that only 50% of the inflow is eventually available for irrigation).

Table 8.30: Key parameters

Parameters	**Value**
Water balance (remaining m^3)	7 800
% water utilised	99.6%
Total gross margin (Rand)	24 279 880
Overhead expenses including interest (Rand)	14 974 325
Net farm income (total)(Rand)	9 305 555
Net farm income (NFI) per ha	18 069
Return on capital investment (NFI/total capital inv.)	13%
Number of permanent equivalent job opportunities	567

Table 8.31: Detailed analysis for 10 Mℓ treated water

Crop	**Total**	**Yield**	**Yield**	**Price**	**Gross**	**Gross**	**Water**	**Water**	**GM include**	**GM**	**% of**	**Area**	**Total water**	**Total GM**
	DAC	**unit**		**/ unit**	**income**	**margin**	**req m3**	**cost**	**water cost**	**per m3**	**are**	**ha**	**m3**	**(Rand)**
Culinary herbs	1751641	kg	42524	48.1	2047500	295859	2400	5040	290819	57.70	3.0%	30	72000	8724562
Flower bulbs	616560	Bulbs	480000	1.5	720000	103440	1160	2436	101004	41.46	2.5%	25	29000	2525100
Rhubarb y4-15	35516	kg	27500	6.976	191840	156324	4160	8736	147588	16.89	2.0%	20	83200	2951760
Cranberries y6-20	40756	Box	320	430	137600	96844	4800	10080	86764	8.61	2.5%	25	120000	2169103
PeachesY5+	30198	2.5kg	3600	30	108000	77802	4160	8736	69066	7.91	2.5%	25	104000	1726643
Peas	21015	Ton	12	5850	70200	49185	3150	6615	42570	6.44	2.0%	20	63000	851399
Dandelion	4265	kg	500	57.3	28660	24395	2400	5040	19355	3.84	2.5%	25	60000	483877
Plums y5+	67731	5kg	3000	35	105000	37269	4160	8736	28533	3.27	2.5%	25	104000	713317
Carrots	41814	Ton	70	1300	91000	49186	5800	12180	37006	3.04	2.0%	20	116000	740120
Brussels	27453	ton	9	5184	46656	19203	2370	4977	14226	2.86	2.0%	20	47400	284520
Strawberries y2	36698	kg	9000	8	72000	35302	4800	10080	25222	2.50	1.5%	15	72000	378328
Asparagus y5+	10713	ton	2	13200	26400	15687	2150	4515	11172	2.47	2.5%	25	53750	279310
Onions	47168	Each	5500	15	82500	35332	5260	11046	24286	2.20	3.5%	35	184100	850010
Raspberries y4	14567	Kg	4000	11.5	46000	31433	4800	10080	21353	2.12	2.5%	25	120000	533833
Potatoes	42500	Bag	3800	15	57000	14500	3090	6489	8011	1.23	10.0%	100	309000	801086
Greenbeans	27546	Ton	15	2767	41505	13959	3220	6762	7197	1.06	2.5%	25	80500	179913
Celery	55976	Ton	10	7170	71700	15724	5800	12180	3544	0.29	1.0%	10	58000	35440
Broccoli	21555	Ton	8	3490	27920	6365	2370	4977	1388	0.28	2.5%	25	59250	34711
Garlic	9658	Kg	1600	9.6	15328	5670	2400	5040	630	0.13	1.0%	10	24000	6300
Clobe artichokes	37146	Kg	6300	8.0	50381.1	13235	5800	12180	1055	0.09	1.0%	10	58000	10550
Lucerne y2-3	6323	Bales	720	25	18000	11677	7200	15120	-3443	-0.23	0.00%	0	0	0
Total											51.5%	515	1817200	24279880

Given all the assumptions, the crop combination will generate a Net Farm Income (NFI) of approximately R18 069 per ha. Assuming that the total capital investment in the purifying plant plus the on-farm capital investment will be approximately R71.4 million for a development of 515 ha the return on capital investment will be approximately 13 percent. The return compares well with observed returns in other regions of the country for similar crop enterprises (e.g. mixed horticultural farms in the Western Cape). Also, the combination will create approximately 567 permanent equivalent job opportunities.

8.13 SUMMARY

Because of many uncertainties it was necessary to make assumptions in this study. However, the consultant is positive that irrigation agriculture could play an important role in the alleviation of the mine water purifying problem, and at the same time create new job opportunities.

The market analysis pointed out that there are opportunities in the market place for high value crops such as herbs and spices, cut flowers and flower bulbs, some of the vegetables as well as for certain berry cultivars.

An illustrative analysis for a 10 Mℓ purification plant indicates a return of approximately 13 percent on total capital investment.

9. INTENSIVE VEGETABLE PRODUCTION IN EASTERN EKURHULENI

Alan Melville, Antonius Leucona
Public Domain Management
Johannesburg

9.1 INTRODUCTION

Two models were considered from the outset for the application of the treated minewater in irrigated agriculture. In the first, all treated water would be absorbed in a single integrated farming operation, and thus enabling the full and efficient control of the cycle of water treatment and utilisation. This has been investigated and reported above in the study by Louw, and for the 10ML/day flow a net farming income of R9.3 million/year, land requirement of 515 ha and the creation of 567 permanent jobs has been indicated.

In the second model the emphasis was directed at utilising the treated water resource for empowerment in terms of entrepreneur development and the involvement of unemployed and informal settlement communities in crop production and crop marketing activities. South Africa has an established track record for the successful use of irrigation schemes in social upliftment programmes (cf. Vaalhartz and Boegoeberg schemes).

Intensive vegetable production on small plots in controlled environment or shade cloth-protected systems was thus taken as the basis for this study of agricultural development in Eastern Ekurhuleni. The variability in the quality of the soils in the area due to previous mining activities also favours intensive production systems. The social implications of the proposal have been considered by Kumalo and de Wet below, and here the feasibility of production was considered principally in terms of:

- The impact of prevailing environmental and climatic factors at the proposed site on crop selection, and
- The market requirements of the area.

The technical aspects of intensive vegetable production in greenhouse or under shade cloth-protected installations are well known and have been described extensively elsewhere.

The general premise underpinning the study was that:

- Vegetable farming is an intensive activity that cannot be undertaken on a part-time or ad-hoc basis, and especially where job creation and empowerment objectives are targeted;
- Urban gardening has been considered but should be seen as a separate undertaking that could, nevertheless, fit into an overall water utilization programme;
- The most beneficial option, and indeed available and sustainable market, is to be found in:

- The production of high-value vegetable products (because they are more difficult to grow and produce) and/or
- The value-added packaging of a range of vegetables into various marketable forms.

Clearly intensive vegetable production is not the only high value agricultural enterprise that might be considered, and substantial components of the above study will find application equally well in the entrepreneur development concept, and would be applicable under intensive production conditions.

9.2 ENVIRONMENTAL CONDITIONS

This section provides an analysis of the environmental factors that have an influence on the design and development of the vegetable farming enterprise. It also provides an overview with recommendations based on climatic data for the area which was obtained from the Weather Bureau and the Agricultural Research Council's Institute of Soil Water and Climate. Soil and water analysis has been reported by Nell above.

9.2.1 Rainfall

Rainfall data is particularly important when developing and designing any farming system, since this data determines whether crops can be grown on a dry land basis, or whether provision must be made for supplemental water via an irrigation system

Figure 9.1 indicates that a period of high rainfall may be expected from November to February each year. The average rainfall is above 200 mm/month during this period. The rainfall pattern is ideal for open vegetable production on a large scale. However it must be stressed that frequent rain does not imply high quality production. Quite often high rainfall areas have higher incidence of pest and diseases.

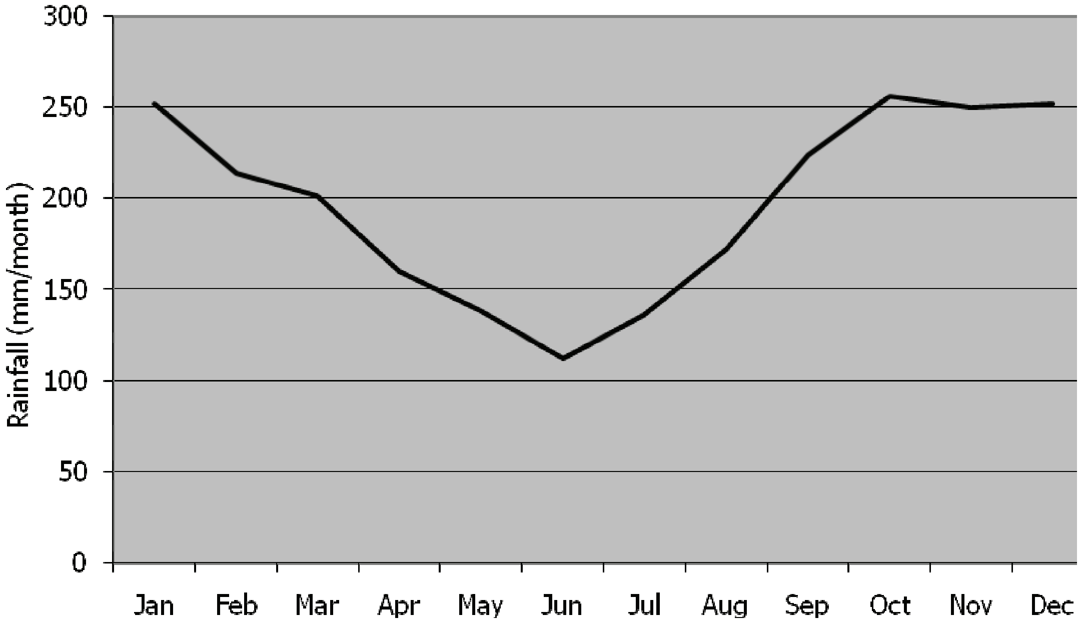


Figure 9.1: Estimated average annual rainfall in Gauteng Province.

9.2.2 Temperature

Temperature is the main factor that determines which crops can be planted in an area, since it has a significant influence on yields, and pest and disease resistance. In order to determine which crops can be planted commercially during the year, a detailed study of the various minimum and maximum temperatures is required. The following temperatures are used in this analysis and are presented in Figure 2:

Tx: Mean daily maximum temperature (°C)
Tm: Mean daily average temperature (°C)
Tn: Mean daily minimum temperature (°C)
Txh: Mean of monthly maxima of maximum temperatures (°C)
Tnl: Mean of monthly minima of minimum temperatures (°C)

Analyses of the mean daily average temperatures (Tm) for the area have shown that average temperature ranges from 1°C during winter to 26°C during summer months.

The mean of monthly maximum temperatures (Txh) indicates that a period of high risk for heat damage exists from October to April, especially to heat sensitive plants.

The average mean of monthly maximum temperatures is 36°C which is high for any crop if it does not have sufficient water. Vegetables would not produce economical yields unless supplemental water is provided during this period.

Cold sensitive plants run a risk of cold damage during the months from May to August. In addition the low temperatures, the earliest occurrence of frost (over the last 10 years) was in the first week of April and the last day of frost occurred during the first week of October. Generally frost occurs in the first week of June and the ends by the first week of August. The frost period extends between 63-185 days. There is a 100 % chance that frost will occur in each year.

Since most of the crops that can be grown in winter are well known to perform under these conditions, especially if there is adequate rainfall. The crops grown during summer months (those under pivot systems and other open irrigation systems) will be limited by climate and growth season length.

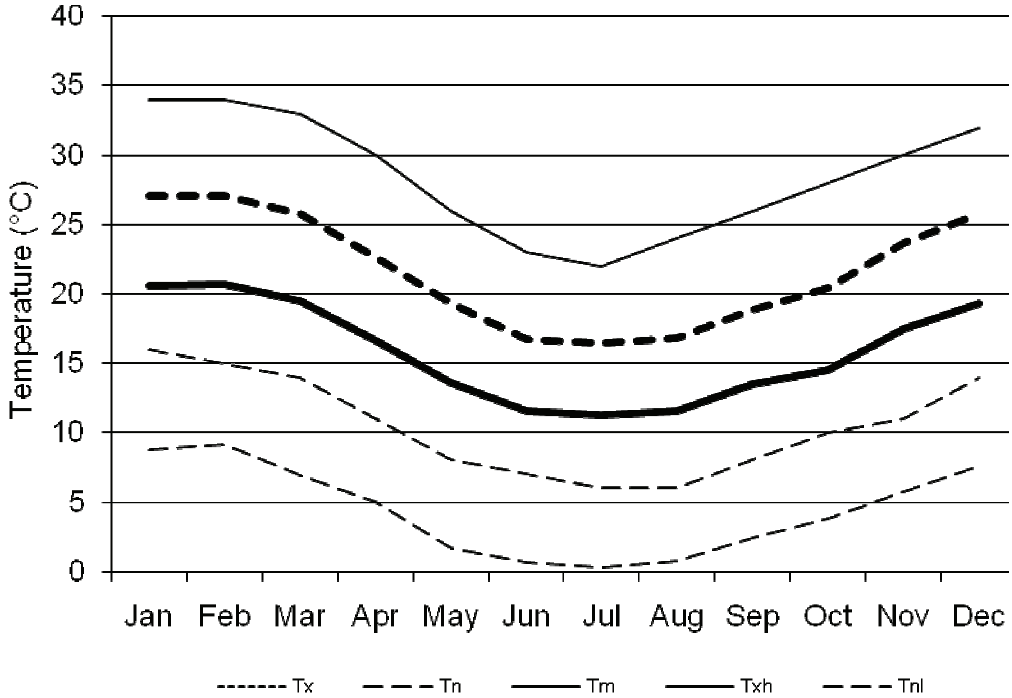


Figure 9.2: Annual average temperature variation in Gauteng Province.

9.2.3 Humidity

Humidity has a significant influence on crop quality. Humidity rather than temperature is often the major limiting factor in open field production systems.

Plants growing at high temperatures, i.e. above 30 °C, experience less stress at higher humidities (above 60 %). For example, the "browning" effect of cauliflower (during the summer months) can be limited by increasing the humidity rather than lowering the temperature. Further, "Tip burn", which is a common physiological disorder found on lettuce during summer at high temperatures, can be negated by cooling the plants down, i.e. increasing the humidity decreases the occurrence of tip burn.

The most effective method of increasing humidity in open field conditions is through overhead sprinkler systems. These systems should be opened for a short period of time, since the desired function is not to moisten the soil, but to apply just enough water on the leaves and soil in order to increase the humidity within the plant micro-climate.

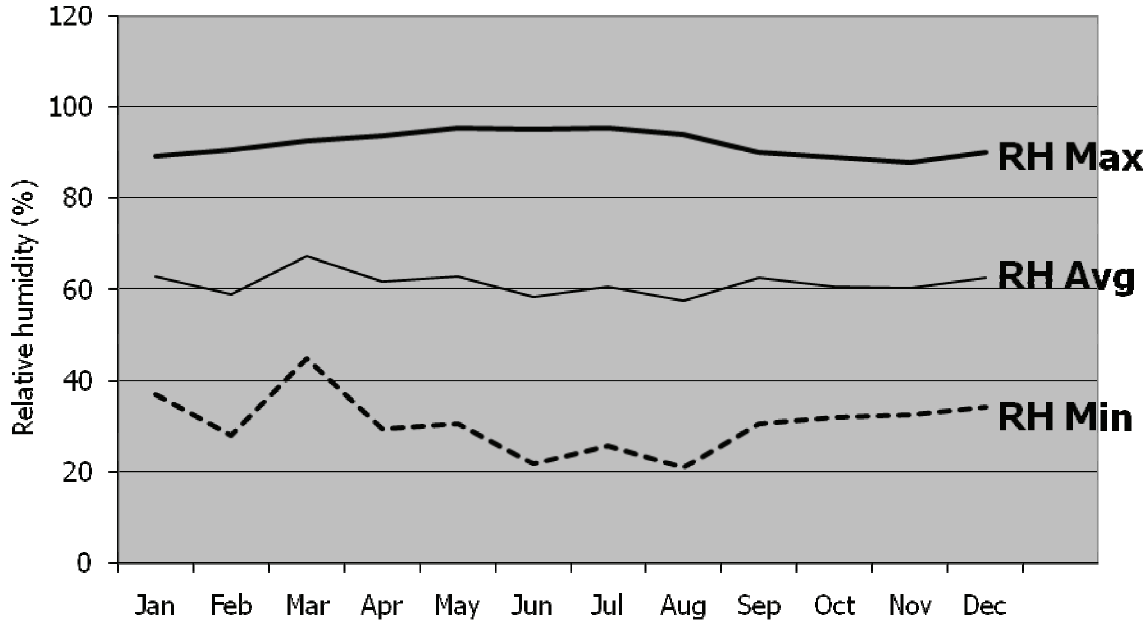


Figure 9.3: Annual average humidity variation in Gauteng Province

9.2.4 Wind

Wind plays a significant role in the types of crops that can be planted, especially if no protection is provided. While there is no wind data available for this area, it is well known that the most farms in the region are exposed to wind, sometimes at gale-force strength, during the course of a year.

The ideal solution is to erect plastic greenhouse or shade cloth covering and, although expensive, it will ensure year round production of high quality produce and is considered strongly desirable where small producers are at continuous high risk. The greenhouse environment can also be adjusted to a certain extent to suit the requirements of a crop. This increases the quality and marketable yields obtained, and it is estimated that an increase of up to 25 % or more can be achieved in this way. Shade houses do not provide as much protection and control as greenhouses, but they protect against the most harmful sun radiation, prevent hail and wind damage to the crop and reduce extremes of temperatures. Yields are also substantially enhanced in these systems.

9.3 MARKET ANALYSIS

9.3.1 Introduction

The marketing of produce should be seen as a long-term undertaking. There are many marketing outlets available in the area and each has its own specific requirements in terms of quality, variety, packaging and quantity. In almost all cases, each market segment requires a "basket" of produce to be delivered. Buyers prefer to limit the number of sources in order to streamline their operations.

At the end of the day, any farming venture, no matter which market is entered or combination are used, should ensure the following:

- Quality
- Consistency
- Quantity

It is important to note that wholesale and retail requirements differ dramatically from region to region, and this fact must be taken into account when comparing markets and prices throughout South Africa.

As an example, it is interesting to note that there is a large difference between the consumer requirements in the Cape compared to Gauteng, where the main difference is in value adding activity. A large percentage of the produce sold in stores in Gauteng (such as Pick 'n Pay) is pre-packed, whereas in the Cape, these are sold in loose units. It appears that the Cape consumer is prepared to pack the produce at home whereas the Gauteng consumers prefer a higher degree of value adding.

There will however always be a market for a crop grown out of season or a crop which is difficult to grow – but, in most cases, a significant capital investment must be made in order to grow and thus benefit from such crops.

9.3.2 Bulk Markets in Gauteng

Johannesburg Fresh Produce Market (JFPM)

The Johannesburg Fresh Produce Market (JFPM) operated by the Municipality of Johannesburg caters for products that are sold in large volumes (in bulk) and in value adding packaging of various types.

The market price system is based on supply and demand, and so prices cannot be guaranteed. Further, not all of the available produce is sold every day – again this depends on the demand for a product and the amount of supply – and produce that is not sold will stay on the floor until the next day. In most cases, these 'leftovers' always receive a lower price than the freshly delivered produce of that day.

Although the JFPM caters for large volumes of value added produce, this does not imply that the quality is inferior to other markets (such as Pick 'n Pay or other stores). In order to ensure that produce is moved quickly and at above the average daily price, the grower must ensure the following:

- The quality must be higher than those of the competitors and
- The Packaging (i.e. bulk presentation) must promote the product.

Throughout our discussions with market agents, all emphasised that the quality of the product will ensure that it is sold, i.e. "quality sells". The market agents prefer selling in bulk to clients. Thus, they prefer selling a pallet at R500/100 units than 100 units at R5.20 each. The reason is that once a pallet is broken up, it becomes more and more difficult to sell the loose units towards the end of the day. This results in some units not being sold and these have to be removed from the market floor due to rotting – and at the grower's cost.

A good example would be the following:

> Currently a farmer's pumpkins are sold per crate. The perception of buyers is that:
> - The Market labour has unpacked the units (unit = 10kg or bag of pumpkins), and in so doing will have damaged some of the units. This perception has been created over the years from experience
> - Buyers assume that other buyers have already been selecting and picking from the loosely packed units, thus resulting in the produce being handled more often than others (usually 25 per block and are stacked on top of each other),
>
> In order to increase the probability that the farm's pumpkins are sold earlier in the morning the following should be done:
> - Units should be packed on pallets in order to prevent people from handling the units separately.
> - The whole pallet should be wrapped in netting to ensure that buyers cannot pick out separate units and that the agents can sell it as a whole.
>
> On average, these two simple aspects will help increasing the price by up to 10 %, and ensure that produce is sold with less "left over".

This principle applies equally to other produce types as well.

Fruit & Vegetable City (FVC)

Fruit & Vegetable City (FVC) caters for the household markets through established vegetable stores. Very little value adding is done.

It is interesting to note that the total sales of FVC are in many cases larger even than those on some of the smaller city markets, e.g. Epping Market in the Cape, where spinach sales at FVC are higher.

The price paid to suppliers is determined by the average market price on the JFPM. In some cases, FVC will have a special for 1-2 weeks and the price will be fixed.
No contracts are provided by FVC, and accredited suppliers should provide a growing program to FVC. FVC would not provide much commitment during our discussions and would need to see our produce, packaging and growth program beforehand.

M & R Agents

M & R Agents are re-packers and supply on contract to the large stores, such as Spar and Pick 'n Pay. As with Fruit & Vegetable City, they buy directly from farms in a packed or bulk form. Their prices are market related and no contracts are provided.

9.3.3 High Value Vegetable Markets

In order to penetrate the high value markets, some form of value adding is required, i.e. the vegetables must either have been processed (to a greater or lesser degree, e.g. peeling and cutting) or must be packed in some type of packaging.

All three companies consulted already have most of their main produce suppliers in place and do not have a shortage in any of the bulkier products such as tomatoes, peppers, onions, potatoes, beetroot, etc. However, some quite exciting market penetration opportunities do still exist.

Pick 'n Pay

Pick 'n Pay have indicated that they would be interested in a variety of specialized crops that are difficult to grow, and the following were mentioned in our discussions:

- Mini or baby corn: Current suppliers are either in Kenya or Zimbabwe
- Sweet corn
- Fine beans
- Baby marrows
- Peas in the shell
- Sugar snaps
- Blanched chicory
- All types of baby vegetables
- Savoy cabbage
- Baby melons
- A limited number of specialty herbs such as Daya and parsley.
- Organically grown produce

Freshmark

Freshmark have a strict policy of first approving a supplier according to the Regulations Governing General Hygiene Requirements for Food Premises and the Transport of Food (Health Act No.63 of 1977). They have a Supplier Hygiene Program and this must be implemented before any produce can be bought.

Whilst they have not indicated finally that they would be interested, they are keen to develop sources for products that are out of season and/or those that are difficult to grow (See the list above under Pick 'n Pay).

Woolworths

At the time of writing formal response via e-mail has not been received. However, it is assumed that the type of market and the requirements are the same as for Pick 'n Pay and Freshmark, with possibly a greater emphasis on quality.

In our initial discussions with Woolworths it was noted that they prefer to buy their produce from packers. Thus contracts are awarded via the pack house company but approved by Woolworths. The main idea behind this operation is to minimize the number of clients that buyers have to deal with.

This is basically the same principle used by Checkers, which operates using Freshmark as their distribution center.

9.3.4 Value Adding Potential

Given enough land, it is entirely feasible that both the bulk markets and value added markets could be targeted. This will ensure that land use is optimized and income maximized. In addition, entering both types of markets will not only distribute risk, but will also provide for a better crop rotation system. Labour use becomes more efficient since not all people have the same abilities. The more specialized and intensive growing methods require special skills and training. This creates opportunities for many people to grow in the jobs.

Unfortunately the South African market is too small for many farmers to specialise in one type of crop. Most high end markets prefer to buy a ‘basket’ of products from one supplier. This ‘basket’ should be selected in such a way that the packaging equipment, which is expensive, be utilized optimally. Further, any down time should preferably be rented out to other farmers to pack their produce.

The product line presented by Pick ‘n Pay fits perfectly since many of the vegetables require the same type of packaging and can thus be packed by the same machine.

The higher end of the market also requires some type of cooling between harvesting and transport to the various markets. It is also important to transport the packed product on refrigerated vehicles.

A list of equipment with estimated cost is provided in Table 9.. These are estimated prices since the exact requirements can only be determined once the amount of produce that needs to be processed per day is known. For instance, the Stretchfilm System varies in price from R 25 000 to R 70 000.

Table 9.1: List of equipment needed to add value to the produce and ease operation during the process.

Equipment	Price	Use
Stretchfilm Systems	±R 25 000	Stretch-wrap butternut and pumpkins on pallets
Minipack	±R25 000	Manual Shrink wrapping punnets for various small produce
Seal Matic Digit System	±R 120 000	Automatic shrink wrap various produce into punnets and labeling

9.4 CROP SELECTION

Recommendation of the crops that could feasibly be grown under open field conditions in this region, and during the different growing periods, are summarized in the tables below. These recommendations are based on the climatic, soil, water quality and market selection criteria dealt with above.

Table 9.2: Summer crops.

Crop type	Botanical Name
Cantaloupe (melons)	*Cucumis melo*
Cucumber (pickle)	*Cucumis sativus*
Egg plant	*Solanum melongena*
Pepper (Hot)	*Capsicum annuum*
Pepper (Sweet)	*Capsicum annuum*
Pumpkin (Ceylon's)	*Cucurbita moshata*
Pumpkin (Hubbard)	*Cucurbita maxima*
Squash (Baby)	*Cucurbita pepo*
Squash (Butternut)	*Cucurbita pepo (Moshata)*
Tomato(Cherryor cocktail)	*Lycopersicon esculentum L.*
Tomato (Fresh market)	*Lycopersicon esculentum L.*
Tomato (Processing)	*Lycopersicon esculentum L.*
Okra	*Abelmoschus esculentus*
Paprika	*Capsicum annuum*
Sweet corn	*Zea mays var. rugosa*
Runner beans	*Phaseolus vulgaris*
Bush bean	*Phaseolus vulgaris*

Table 9.3: Winter crops.

Crop name	Botanical Name
Radicchio	*Cichorium intybus*
Broccoli	*Brassica oleraceae*
Cauliflower	*Brassica oleraceae*
Chinese cabbage	*Brassica pekinensis*
Brussels Sprouts	*Brassica oleraceae*
Celery	*Appium graveolens*
Turnip	*Brassica rapa*
Kohlrabi	*Brassica oleraceae*
Radish	*Raphanus sativus L.*
Peas	*Pisum sativum L.*

Table 9.4: Late summer crops that grow through to early spring.

Crop name	Botanical Name
Spinach	*Spinasia oleraceae*
Cabbage	*Brassica oleraceae*
Lettuce	*Lactuca sativa*
Beet root	*Beta vulgaris var. conditivy*
Garden bean	*Phaseolus vulgaris*
Garden peas	*Pisum sativum*
Parsley	*Petroselinum crispum*
Parsnip	*Pastinacy satica*
Swiss chard	*Beta vulgaris*
Artichoke (Globe)	*Cynara scolymus*
Rhubarb	*Rheumrhaponticum*
Scorzonera (Salsify)	*Tragopogon porifolius*

However, if structures such as shade houses or greenhouses are erected, many more crops could profitably be grown. For instance, it would be possible to grow cauliflower during the whole year. Further, and by way of example, the quality of cauliflower, especially during summer months is Gauteng, can also be improved significantly by erecting shade houses.

9.5 PROGRAMME

While a wide range of crops may be grown under irrigation in the Gauteng region, at various times of the year a typical production program is presented in Table 9.5.

This system assumes the use of 25 ha under shade cloth, however, open field production of the some crops can be included. The following crops can be grown using both structures throughout the year and may be prepared for market using the same packaging systems:

Table 9.5: List of crops with available markets that can be grown under both shade cloth structures and pivot irrigated system.

Crop	Shade cloth		Open field	
	Summer	Winter	Summer	Winter
Spring onions	X	X		
Celery	X	X		X
Green beans	X			
Green peppers	X			
Orange peppers	X			
Red peppers	X			
Yellow peppers	X			
Cauliflower	X	X		X
Broccoli	X	X		X
Butternut			X	
Green beans	X			
Sweet corn			X	
Baby cabbage types	X	X		X
Baby cauliflower	X	X		X
Baby Chinese cabbage	X	X		X
Fine beans	X			
Baby marrows	X			
Romanesca	X	X		X
Baby peppers (Baby Bell)	X			

9.6 PLANNING THE ENTERPRISE

A detailed analysis of the market was undertaken as related to planning of the vegetable production enterprise, and the results of this analysis are reported in the Tables 9.6-9.9.

Table 9.6 Estimated market size
Table 9.7 Estimated production potential
Table 9.8 Average prices
Table 9.9 Estimated gross returns

The planning and costing structure for a 25 ha vegetable production unit was investigated and the results have been reported in Tables 9.10-9.17.

Table 9.10 Production programme for 25 ha unit
Table 9.11 Gross income on 25 ha unit
Table 9.12 Packaging coats on 25 ha unit
Table 9.13 Seedling costs on 25 ha unit
Table 9.14 Fertilizer costs on 25 ha unit
Table 9.15 Labour costs on 25 ha unit
Table 9.16 Chemical costs on 25 ha unit
Table 9.17 Direct allocated variable costs on 25 ha unit.

Table 9.6: Estimated market size gathered from a fresh produce market, local contracts and Pick 'n Pay requirements.

Crop	Packaging	Size	Kg											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spring onions	Per 10 bunches		1244	871	835	479	587	770	965	818	895	828	1158	1220
Celery	Per 10 bunches		372	135	999	3162	7239	5091	9432	7062	2880	2118	1308	699
Coriander	Double layer	5	0	25	115	585	300	280	125	420	100	0	95	0
	Single layer	3	6360	6939	3720	6405	7971	5076	6594	8145	7569	9498	8217	7680
Coriander	Per 10 bunches		275	203	100	0	0	0	63	40	228	268	628	538
Parsley	Per 10 bunches		6555	8388	4513	5555	6103	5238	7048	6975	5030	7285	7210	8275
Green beans	Double layer	6	12180	4830	44562	32742	22122	28782	52554	112956	137442	86988	10038	9180
	Standard pocket	10	159190	193050	154710	223040	280650	158680	66720	5730	10460	116110	225930	142030
	Single layer	3.5	886	364	693	1865	6514	4473	9429	17255	36656	24462	1747	336
Green peppers	Double layer	6	207498	182880	120408	128706	159036	154572	223914	201546	171390	228624	235374	261726
	Standard pocket	7.5			169785	1608218	121665	63323						
	Single layer	2.5	823	680	793	438	4278	4980	7313	3958	6518	2810	220	2715
Orange peppers	Double layer	6	204	330	156	210	756	570	426	936	246	36		
Red peppers	Double layer	6	45600	29682	22596	29916	25158	21948	41130	47580	45702	26220	67452	73842
	Single layer	2.5	265	830	328	275	135	980	1398	3813	2390	2513	233	795
Yellow peppers	Double layer	6	28776	11298	17784	19512	16032	16320	17178	23100	30168	12402	25692	35502
	Single layer	2.5	103	720	360	83	123	228	2320	2915	780	1335	105	223
Cauliflower	Heads		10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
Broccoli	Heads		10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
Butternut	Pocket	10	5000	5000	5000	5000							5000	5000
Green beans	Punnet	2	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Baby corn	Kg		1000	1000	1000									
Sweet corn	Cobs		30000	30000	30000									
Baby cabbage types	Heads		8400	8400	8400	8400	8400	8400	8400	8400	8400	8400	8400	8400
Baby cauliflower	Heads		11200	11200	11200	11200	11200	11200	11200	11200	11200	11200	11200	11200
Baby Chinese cabbage	Heads				11200	11200	11200	11200	11200	11200	11200			
Fine beans	Kg				800	800	800	800	800	800	800			
Baby marrows	Kg		5000	5000	5000	5000							5000	5000
Peas in the shell	Kg							350	350	350	350	350		
Sugar snaps	Kg						350	350	350	350	350	350		
Romanesca	Heads		7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500
Blanched chicory	Kg			500	500	500	500							
Baby Savoy cabbage	Heads				11200	11200	11200	11200	11200	11200	11200			
Savoy cabbage	Heads		2700	2700	2700	2700	2700	2700	2700	2700	2700	2700	2700	2700
Daya (Coriander)	Kg						350.00	350.00	350.00	350.00	350.00	350.00		
Baby peppers (Baby Bell)	Kg		1000	1000	1000	1000							1000	1000

Table 9.7: Estimated potential production of various vegetables that can be grown on a farm in Gauteng.

Crop	Packaging	m²	Production (see packaging for unit of measure)											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spring onions	Per 10 bunches	2500	1042	1042	1042	1042	1042	1042	1042	1042	1042	1042	1042	1042
Celery	Per 10 bunches	10000	333	333	333	333	333	333	333	333	333	333	333	333
Coriander	Double layer	5000	71	71	71	71	71	71	71	71	71	71	71	71
	Single layer	5000	71	71	71	71	71	71	71	71	71	71	71	71
Coriander	Per 10 bunches	5000	70	70	70	70	70	70	70	70	70	70	70	70
Parsley	Per 10 bunches	5000	500	500	500	500	500	500	500	500	500	500	500	500
Green beans	Double layer	2500	750	750	750	750								750
	Standard pocket	2500	750	750	750	750								750
	Single layer	2500	750	750	750	750								750
Green peppers	Double layer	5000	6000	6000	6000	2000								2000
	Standard pocket	5000	6000	6000	6000	2000								2000
	Single layer	5000	6000	6000	6000	2000								2600
Orange peppers	Double layer	5000	6000	6000	6000	2000								2000
Red peppers	Double layer	5000	6000	6000	6000	2000								2000
	Single layer	5000	6000	6000	6000	2000								2000
Yellow peppers	Double layer	5000	6000	6000	6000	2000								2000
	Single layer	5000	6000	6000	6000	2000								2000
Cauliflower	each in punnet	30000	11700	11700	11700	11700	11700	11700	11700	11700	11700	11700	11700	11700
Broccoli	each in punnet	30000	11700	11700	11700	11700	11700	11700	11700	11700	11700	11700	11700	11700
Butternut	Pocket	30000	7500	7500	5000								1500	3750
Green beans	Punnet	30000	11250	11250	11250	8500						2800	5600	11250
Baby corn	Kg	6000	1111	1111	1111									
Sweet corn	per 4 cobs	150000	30000	30000	30000									
Baby cabbage types	per head	10000	8400	8400	8400	8400	8400	8400	8400	8400	8400	8400	8400	8400
Baby cauliflower	per head	13440	11200	11200	11200	11200	11200	11200	11200	11200	11200	11200	11200	11200
Baby Chinese cabbage	per head	8000			11200	11200	11200	11200	11200	11200	11200			
Fine beans	Kg	2500	750	750	750	750								750
Baby marrows	Kg	2500	5000	5000	5000	5000							5000	5000
Peas in the shell	Kg	500					350	350	350	350	350	350		
Sugar snaps	Kg	500					350	350	350	350	350	350		
Romanesca	Heads	18000	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500
Blanched chicory	Kg			500	500	500	500							
Baby Savoy cabbage	per head	5000			11200	11200	11200	11200	11200	11200	11200			
Savoy cabbage	per head	6000	2700	2700	2700	2700	2700	2700	2700	2700	2700	2700	2700	2700
Dhaya (Coriander)	Kg	3000					350	350	350	350	350	350		
Baby peppers (Baby Bell)	Kg	12000	1000	1000	1000	1000							1000	1000

Table 9.8: Average price obtained for various vegetables during the 2002 season on fresh produce markets in South Africa.

Crop	Packaging	Units	R/kg											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spring onions	Per 10 bunches	Average	12.57	15.23	8.89	10.31	10.35	12.91	14.11	14.50	13.50	12.61	14.53	14.11
Celery	Per 10 bunches	Average	11.90	40.27	11.89	12.85	11.24	13.94	13.42	8.78	8.62	7.78	19.30	10.37
Coriander	Double layer	Average	3.00	3.03	4.96	3.14	2.60	3.11	5.12	2.81	2.04		0.35	
	Single layer	Average	4.23	4.37	6.94	5.31	4.27	4.82	6.94	5.18	3.28	3.15	4.18	4.39
Coriander	Per 10 bunches	Average	4.97	4.99	10.85				5.02	1.83	4.20	5.10	4.71	4.38
Parsley	Per 10 bunches	Average	12.11	15.74	8.58	11.71	10.26	9.96	9.12	8.87	8.28	7.60	8.48	8.87
Green beans	Double layer	Average	3.70	3.86	3.23	3.08	2.64	4.22	5.20	4.10	2.77	3.28	4.32	4.96
	Standard pocket	Average	2.43	2.11	1.50	1.44	1.46	2.45	2.67	3.05	2.29	2.61	3.12	2.56
	Single layer	Average	3.90	2.28	14.77	14.43	11.27	7.03	8.07	6.38	4.29	4.64	4.97	9.33
Green peppers	Double layer	Average	3.61	2.72	5.17	4.36	3.24	3.27	2.96	4.31	5.74	5.65	4.58	4.60
	Standard pocket	Average			1.47	1.39	1.22	1.30						
	Single layer	Average	10.95	7.47	7.86	6.00	3.46	7.50	9.13	12.32	16.37	11.47	4.20	13.57
Orange peppers	Double layer	Average	2.79	1.98	7.18	8.57	4.13	4.61	6.29	4.37	6.89	5.83		
Red peppers	Double layer	Average	6.44	8.33	9.12	10.76	8.23	6.77	7.36	4.51	6.79	12.92	6.60	5.53
	Single layer	Average	13.57	27.02	8.97	31.64	11.99	14.10	14.27	10.06	11.45	29.98	10.56	7.72
Yellow peppers	Double layer	Average	6.73	10.35	8.74	12.03	7.34	6.39	9.09	5.42	6.93	10.32	8.85	7.32
	Single layer	Average	7.41	23.92	9.29	27.76	10.47	12.57	19.32	14.08	14.69	25.75	19.95	17.15
Cauliflower	Punnet	Per punnet	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Broccoli	Punnet	Per punnet	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Butternut	Pocket	Average	0.50	0.53	0.70	0.64	0.88	1.08	2.01	3.77	5.36	1.70	0.80	0.50
Green beans	Punnet	Average	1.05	0.66	0.66	0.95	0.95	0.88	1.10	1.22	2.13	2.79	2.76	2.07
Baby corn	Punnet	kg	38	38	38	38	38	38	38	38	38	38	38	38
Sweet corn	Punnet	per 4 cobs	6	6	6	6	6	6	6	6	6	6	6	6
Baby cabbage types	Punnet	per head	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Baby cauliflower	Punnet	per head	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Baby Chinese cabbage	Punnet	per head	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Fine beans	Punnet	kg	20	20	20	20	20	20	20	20	20	20	20	20
Baby marrows	Punnet	kg	10	10	10	10	10	10	10	10	10	10	10	10
Peas in the shell	Punnet	kg	28	28	28	28	28	28	28	28	28	28	28	28
Sugar snaps	Punnet	kg	28	28	28	28	28	28	28	28	28	28	28	28
Romanesca	Punnet	kg	9	9	9	9	9	9	9	9	9	9	9	9
Blanched chicory	Punnet	kg	35	35	35	35	35	35	35	35	35	35	35	35
Baby Savoy cabbage	Punnet	per head	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Savoy cabbage	Punnet	per head	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Daya (Coriander)	Punnet	kg	44	44	44	44	44	44	44	44	44	44	44	44
Baby peppers (Baby Bell)	Punnet	kg	15	15	15	15	15	15	15	15	15	15	15	15

Table 9.9: Estimated gross return on various crops grown on varying areas in order to meet market demand.

Crop	Packaging	m²	Gross return											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spring onions	Per 10 bunches	2500	13094	15865	9260	10740	10781	13448	14698	15104	14063	13135	15135	14698
Celery	Per 10 bunches	10000	3967	13423	3963	4283	3747	4647	4473	2927	2873	2593	6433	3457
Coriander	Double layer	5000	213	215	351	222	184	220	363	199	145	0	25	0
	Single layer	5000	300	310	492	376	302	341	492	367	232	223	296	311
Coriander	Per 10 bunches	5000	348	349	760	0	0	0	351	128	294	357	330	307
Parsley	Per 10 bunches	5000												
Green beans	Double layer	2500	2771	2895	2420	2310	0	0	0	0	0	0	0	3721
	Standard pocket	2500	1823	1585	1124	1082	0	0	0	0	0	0	0	1922
	Single layer	2500	2925	1710	11078	10823	0	0	0	0	0	0	0	6998
Green peppers	Double layer	10000	21660	16320	31020	8720	0	0	0	0	0	0	0	9200
	Standard pocket	5000	0	0	8820	2780	0	0	0	0	0	0	0	0
	Single layer	10000	65700	44820	47160	12000	0	0	0	0	0	0	0	27140
Orange peppers	Double layer	5000	16740	11880	43080	17140	0	0	0	0	0	0	0	0
Red peppers	Double layer	10000	38640	49980	54720	21520	0	0	0	0	0	0	0	11060
	Single layer	10000	81420	162120	53820	63280	0	0	0	0	0	0	0	15440
Yellow peppers	Double layer	5000	40380	62100	52440	24060	0	0	0	0	0	0	0	14640
	Single layer	5000	40380	62100	52440	24060	0	0	0	0	0	0	0	14640
Cauliflower	each in punnet	30000	16380	16380	16380	16380	16380	16380	16380	16380	16380	16380	16380	16380
Broccoli	each in punnet	30000	16380	16380	16380	16380	16380	16380	16380	16380	16380	16380	16380	16380
Butternut	Pocket	30000	3750	3975	3500	0	0	0	0	0	0	0	1200	1875
Green beans	Punnet	30000	11813	7425	7425	8075	0	0	0	0	0	7812	15456	23288
Baby corn	Punnet	6000	42218	42218	42218	0	0	0	0	0	0	0	0	0
Sweet corn	per 4 cobs punnet	150000	45000	45000	45000	0	0	0	0	0	0	0	0	0
Baby cabbage types	Punnet	10000	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500
Baby cauliflower	Punnet	13440	14000	14000	14000	14000	14000	14000	14000	14000	14000	14000	14000	14000
Baby Chinese cabbage	Punnet	8000	0	0	14000	14000	14000	14000	14000	14000	14000	0	0	0
Fine beans	Punnet	2500	15000	15000	15000	15000	0	0	0	0	0	0	0	15000
Baby marrows	Punnet	2500	50000	50000	50000	50000	0	0	0	0	0	0	50000	50000
Peas in the shell	Punnet	500	0	0	0	0	9800	9800	9800	9800	9800	9800	0	0
Sugar snaps	Punnet	500	0	0	0	0	9800	9800	9800	9800	9800	9800	0	0
Romanesca	Punnet	18000	13500	13500	13500	13500	13500	13500	13500	13500	13500	13500	13500	13500
Blanched chicory	Punnet	0	0	17500	17500	17500	17500	0	0	0	0	0	0	0
Baby Savoy cabbage	Punnet	5000	0	0	14000	14000	14000	14000	14000	14000	14000	0	0	0
Savoy cabbage	Punnet	6000	3375	3375	3375	3375	3375	3375	3375	3375	3375	3375	3375	3375
Daya (Coriander)	Punnet	3000	0	0	0	0	15400	15400	15400	15400	15400	15400	0	0
Baby peppers (Baby Bell)	Punnet	12000	15000	15000	15000	15000	0	0	0	0	0	0	15000	15000

Table 9.10: Possible production program using 25 ha under shade cloth.

Crop	Packaging	m^2	Production (see packaging for unit of measure)											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spring onions	Per 10 bunches	2500	1042	1042	1042	1042	1042	1042	1042	1042	1042	1042	1042	1042
Celery	Per 10 bunches	10000	333	333	333	333	333	333	333	333	333	333	333	333
Parsley	Per 10 bunches	5000	500	500	500	500	500	500	500	500	500	500	500	500
Green beans	Double layer	2500	750	750	750	750								750
	Standard pocket	2500	750	750	750	750								750
	Single layer	2500	750	750	750	750								750
Green peppers	Double layer	5000	6000	6000	6000	2000								2000
	Standard pocket	5000	6000	6000	6000	2000								2000
	Single layer	5000	6000	6000	6000	2000								2000
Orange peppers	Double layer	5000	6000	6000	6000	2000								2000
Red peppers	Double layer	5000	6000	6000	6000	2000								2000
	Single layer	5000	6000	6000	6000	2000								2000
Yellow peppers	Double layer	5000	6000	6000	6000	2000								2000
	Single layer	5000	6000	6000	6000	2000								2000
Cauliflower	each in punnet	30000	11700	11700	11700	11700	11700	11700	11700	11700	11700	11700	11700	11700
Broccoli	each in punnet	30000	11700	11700	11700	11700	11700	11700	11700	11700	11700	11700	11700	11700
Butternut	Pocket	30000	7500	7500	5000								1500	3750
Green beans	Punnet	30000	11250	11250	11250	8500						2800	5600	11250
Sweet corn	per 4 cobs	150000	30000	30000	30000									
Baby cabbage types	per head	10000	8400	8400	8400	8400	8400	8400	8400	8400	8400	8400	8400	8400
Baby cauliflower	per head	13440	11200	11200	11200	11200	11200	11200	11200	11200	11200	11200	11200	11200
Baby Chinese cabbage	per head	8000			11200	11200	11200	11200	11200	11200	11200			
Fine beans	Kg	2500	750	750	750	750								750
Baby marrows	Kg	2500	5000	5000	5000	5000							5000	5000
Romanesca	Heads	18000	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500
Baby peppers (Baby Bell)	Kg	12000	1000	1000	1000	1000							1000	1000

Table 9.11: Potential gross income based on market requirements, market prices provided and production potential of the area.

Crop	R											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spring onions	13094	15865	9260	10740	10781	13448	14698	15104	14063	13135	15135	14698
Celery	3967	13423	3963	4283	3747	4647	4473	2927	2873	2593	6433	3457
Green beans	2771	2895	2420	2310	0	0	0	0	0	0	0	3721
	1823	1585	1124	1082	0	0	0	0	0	0	0	1922
	2925	1710	11078	10823	0	0	0	0	0	0	0	6998
Green peppers	21660	16320	31020	8720	0	0	0	0	0	0	0	9200
	0	0	8820	2780	0	0	0	0	0	0	0	0
	65700	44820	47160	12000	0	0	0	0	0	0	0	27140
	16740	11880	43080	17140	0	0	0	0	0	0	0	0
Orange peppers	38640	49980	54720	21520	0	0	0	0	0	0	0	11060
Red peppers	81420	162120	53820	63280	0	0	0	0	0	0	0	15440
	40380	62100	52440	24060	0	0	0	0	0	0	0	14640
Yellow peppers	40380	62100	52440	24060	0	0	0	0	0	0	0	14640
	44460	143520	55740	55520	0	0	0	0	0	0	0	34300
Cauliflower	16380	16380	16380	16380	16380	16380	16380	16380	16380	16380	16380	16380
Broccoli	3750	3975	3500	0	0	0	0	0	0	0	1200	1875
Butternut	11813	7425	7425	8075	0	0	0	0	0	7812	15456	23288
Green beans	31500	7425	7425	10688	8075	0	0	0	0	0	7728	11592
Baby cabbage types	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500
Baby cauliflower	14000	14000	14000	14000	14000	14000	14000	14000	14000	14000	14000	14000
Baby Chinese cabbage	0	0	14000	14000	14000	14000	14000	14000	14000	0	0	0
Fine beans	15000	15000	15000	15000	0	0	0	0	0	0	0	15000
Baby marrows	50000	50000	50000	50000	0	0	0	0	0	0	50000	50000
Romanesca	13500	13500	13500	13500	13500	13500	13500	13500	13500	13500	13500	13500
Baby peppers (Baby Bell)	15000	15000	15000	15000	0	0	0	0	0	0	15000	15000
Monthly totals	555403	741523	593815	425461	90983	86475	87551	86411	85316	77920	165332	328351
Grand total												3324541

Table 9.12: Packaging cost based on proposed production system

Crop	R/unit	Unit	Packaging cost											
			Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Spring onions	R 0.75	0.10	781	781	781	781	781	781	781	781	781	781	781	781
Celery	R 0.65	1.00	2167	2167	2167	2167	2167	2167	2167	2167	2167	2167	2167	2167
Parsley	R 0.85	0.20	850	850	850	850	850	850	850	850	850	850	850	850
Green beans	R 5.85	6	731	731	731	731	731	731	731	731	731	731	731	731
	R 2.85	10	214	214	214	214	214	214	214	214	214	214	214	214
	R 3.85	3.5	825	825	825	825	825	825	825	825	825	825	825	825
Green peppers	R 1.60	0.40	8000	8000	8000	0	0	0	0	0	0	0	8000	8000
	R 1.60	0.40	8000	8000	8000	0	0	0	0	0	0	0	8000	8000
	R 1.60	0.40	8000	8000	8000	0	0	0	0	0	0	0	8000	8000
Orange peppers	R 1.60	0.40	8000	8000	8000	0	0	0	0	0	0	0	8000	8000
Red peppers	R 1.60	0.40	8000	8000	8000	0	0	0	0	0	0	0	8000	8000
	R 1.60	0.40	8000	8000	8000	0	0	0	0	0	0	0	8000	8000
Yellow peppers	R 1.60	0.40	8000	8000	8000	0	0	0	0	0	0	0	8000	8000
	R 1.60	0.40	8000	8000	8000	0	0	0	0	0	0	0	8000	8000
Cauliflower *	R 0.85	1.00	9945	9945	9945	9945	9945	9945	9945	9945	9945	9945	9945	9945
Broccoli *	R 0.85	1.00	9945											
Butternut *	R 4.60	1.00	34500	34500	23000	0	0	0	0	0	0	0	6900	17250
Green beans	R 0.85	0.40	23906	23906	23906	18063	0	0	0	0	0	5950	11900	23906
Baby cabbage types	R 0.85	1.00	7140	7140	7140	7140	7140	7140	7140	7140	7140	7140	7140	7140
Baby cauliflower	R 0.85	1.00	9520	9520	9520	9520	9520	9520	9520	9520	9520	9520	9520	9520
Baby Chinese cabbage	R 0.85	1.00	0	0	9520	9520	9520	9520	9520	9520	9520	0	0	0
Fine beans	R 0.85	0.30	2125	2125	2125	2125	0	0	0	0	0	0	0	2125
Baby marrows	R 0.85	0.40	10625	10625	10625	10625	0	0	0	0	0	0	10625	10625
Romanesca	R 0.85	1.00	6375	6375	6375	6375	6375	6375	6375	6375	6375	6375	6375	6375
Baby peppers (Baby Bell)	R 1.60	0.25	6400	6400	6400	6400	0	0	0	0	0	0	6400	6400
TOTAL:			190049	180104	178124	85280	48068	48068	48068	48068	48068	44498	138373	162854

Table 9.13: Seedling cost based on proposed production system

Crop	Seedlings											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Spring onions	880	880	880	880	880	880	880	880	880	880	880	880
Celery	283	283	283	283	283	283	283	283	283	283	283	283
Parsley	22	22	22	22	22	22	22	22	22	22	22	22
Green beans	1155	1155							1155	1155	1155	1155
	1155	1155							1155	1155	1155	1155
	1155	1155							1155	1155	1155	1155
Green peppers									5600			
									5600			
									5600			
Orange peppers									5600			
Red peppers									5600			
									5600			
Yellow peppers									5600			
									5600			
Cauliflower *	994	994	994	994	994	994	994	994	994	994	994	994
Broccoli *	994	994	994	994	994	994	994	994	994	994	994	994
Butternut *	549	549							549	549	549	549
Green beans	1155	1155							1155	1155	1155	1155
Baby cabbage types	1428	1428	1428	1428	1428	1428	1428	1428	1428	1428	1428	1428
Baby cauliflower	1904	1904	1904	1904	1904	1904	1904	1904	1904	1904	1904	1904
Baby Chinese cabbage			1904	1904	1904	1904	1904	1904	1904	0	0	0
Fine beans	13860	13860							13860	13860	13860	13860
Baby marrows	3000								3000			3000
Romanesca	1275	1275	1275	1275	1275	1275	1275	1275	1275	1275	1275	1275
Baby peppers (Baby Bell)									3000			
TOTAL	**29811**	**26811**	**9686**	**9686**	**9686**	**9686**	**9686**	**9686**	**79515**	**26811**	**26811**	**29811**

Table 9.14: Fertilizer cost based on proposed production system

Crop	m²	Fertilizer											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spring onions	2500	208	208	208	208	208	208	208	208	208	208	208	208
Celery	10000	833	833	833	833	833	833	833	833	833	833	833	833
Parsley	5000	417	417	417	417	417	417	417	417	417	417	417	417
Green beans	2500	208	208	208						208	208	208	208
	2500	208	208	208						208	208	208	208
	2500	208	208	208						208	208	208	208
Green peppers	5000	625	625	625						625	625	625	625
	5000	625	625	625						625	625	625	625
	5000	625	625	625						625	625	625	625
Orange peppers	5000	625	625	625						625	625	625	625
Red peppers	5000	625	625	625						625	625	625	625
	5000	625	625	625						625	625	625	625
Yellow peppers	5000	625	625	625						625	625	625	625
	5000	625	625	625						625	625	625	625
Cauliflower *	30000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Broccoli *	30000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Butternut *	30000	750								750	750	750	750
Green beans	30000	750	750	750						750	750	750	750
Baby cabbage types	10000	250	250	250	250	250	250	250	250	250	250	250	250
Baby cauliflower	13440	450	450	450	450	450	450	450	450	450	450	450	450
Baby Chinese cabbage	8000	200	200	200	200	200	200	200	200	200	200	200	200
Fine beans	2500	200	200	200	200	200	200	200	200	200	200	200	200
Baby marrows	2500	350	350	350					350	350	350	350	350
Romanesca	18000	450	450	450	450	450	450	450	450	450	450	450	450
Baby peppers (Baby Bell)	12000	1200	1200	1200						1200	1200	1200	1200
TOTAL		13683	12933	12933	5008	5008	5008	5008	5358	13683	13683	13683	13683

Table 9.15: Labour cost based on proposed production system

Crop	m²	Production (see packaging for unit of measure)											
		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Spring onions	2500	3	3	3	3	3	3	3	3	3	3	3	3
Celery	10000	4	4	4	4	4	4	4	4	4	4	4	4
Parsley	5000	3	3	3	3	3	3	3	3	3	3	3	3
Green beans	2500	4	4	4	4					5	1	1	5
	2500												
	2500												
Green peppers	5000	20	20	20	10					30	10	5	7
	5000												
	5000												
Orange peppers	5000												
Red peppers	5000												
	5000												
Yellow peppers	5000												
	5000												
Cauliflower *	30000	4	4	4	4	4	4	4	4	4	4	4	4
Broccoli *	30000	4	4	4	4	4	4	4	4	4	4	4	4
Butternut *	30000	5	5	5						5	4	4	5
Green beans	30000	5	5	5	5					5	2	2	5
Baby cabbage types	10000	4	4	4	4	4	4	4	4	4	4	4	4
Baby cauliflower	13440												
Baby Chinese cabbage	8000												
Fine beans	2500												
Baby marrows	2500	5	5	5	5					10	2	2	5
Romanesca	18000	4	4	4	4	4	4	4	4	4	4	4	4
Baby peppers (Baby Bell)	12000	3	3	3	3					10	4	2	2
Man days per month		20	20	20	20	20	20	20	20	20	20	20	20
Total man days		1360	1360	1360	1060	520	520	520	520	1820	980	840	1100
R50/man-day		68000	68000	68000	53000	26000	26000	26000	26000	91000	49000	42000	55000

Table 9.16: Chemical spray cost based on proposed production system

Crop	Seedlings											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fungicide				10000				45000				
Pesticide				5000				30000				
Herbicide								10000				
TOTAL				15000				85000				

Table 9.17: Summary of direct allocated variable costs for the proposed system (R)

Component	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Packaging	190049	180104	178124	85280	48068	48068	48068	48068	48068	44498	138373	162854	1219622
Seedlings	29811	26811	9686	9686	9686	9686	9686	9686	79515	26811	26811	29811	277686
Fertilizers	13683	12933	12933	5008	5008	5008	5008	5358	13683	13683	13683	13683	119671
Labour	68000	68000	68000	53000	26000	26000	26000	26000	91000	49000	42000	55000	598000
Chemicals				15000				85000					100000
TOTAL	301543	287848	268743	167974	88762	88762	88762	174112	232266	133992	220867	261348	2314979

9.7 WATER UTILISATION OPTIONS

A number of water use options may be considered based on the analysis developed above.

9.7.1 Option 1: Return Water to Stream

Although this is likely to be the preferred option from a total catchment water management policy perspective, it is obviously the least attractive option in the job creation and empowerment scenario, and especially where job creation is a specifically targeted objective. In the case of the Blesbokspruit wetland, special circumstances of overload prevail and it has been considered desirable to reduce hydraulic flows through the system. Since the decision is outside the mandate of this proposal, it will not be dealt with further here.

9.7.2 Option 2: The Agri-business Model

The availability of large volumes of treated water, suitable for both industrial and agricultural use will provide a valuable resource and also do much to promote the Ekurhuleni Metro vision for the area as a region driven by agricultural development.

While this study did not deal with the industrial development potential that could quite feasibly take advantage of the availability of the water as mentioned, it did focus on the potential agri-business opportunities that could be developed in the area. Proximity to the main Gauteng markets of Johannesburg and Pretoria present major opportunities in this regard. This model fits the entrepreneurship empowerment objective, which would need to be focused rigorously on best practice agri-business principles.

The following examples serve to illustrate the sustainable economic development potential for the area and cost calculations have been based on the data tabulated above:

9.7.2.1 Intensive Climate Controlled Hydroponic Systems

Based on the results of the social dynamics survey undertaken in the area by Kumalo and de Wet reported below, this is the most preferred option for implementation in the context of the Springs/Nigel SDI corridor, and more especially in the socio-economic context of the Daggafontein community. It was their observation that the creation of capacity for a large number of new jobs, without the community necessarily being required to source capital, or indeed have the requisite skills to implement and sustainably operate the system, would provide the most immediate benefit. This could function quite satisfactorily side by side with an urban gardening or community-based initiative.

The controlled environment is considered to be advisable for the smaller producer, and especially where risk and losses associated with open land production systems

cannot be sustained financially. Also the quality of the old mining ground available favours the use of hydroponic systems. However, crop production and disease control management constraints are rigorous, and this system would favour larger, and more professionally trained producers.

A full scale-commercial climate controlled hydroponic unit would have the following financial profile:

Capital Cost	R1 250 000	per hectare (minimum)
Annual Net Income	R228 094	per hectare (based on 3 vegetables)
Job Creation	2,5 persons	per hectare
Water Usage	60 000 ℓ	per hectare per day
NPV	R194 518	(prime = 11.5%)

9.7.2.2 Shade-cloth Covered Hydroponic System

The use of shade cloth covered hydroponics has many of the advantages outlined above for the environment controlled system, although the technicalities of management control are not as rigorous. Yields are also somewhat lower. This system would also have communal farming potential, assuming that the appropriate support and training resources were made available.

Capital Cost	R750 000	per hectare (minimum)
Annual Net Income	R150 392	per hectare (based on 3 vegetables)
Job Creation	2,5 persons	per hectare
Water Usage	60 000 ℓ	per hectare per day
NPV	R194 781	(prime = 11.5%)

9.7.3 Option 3: Urban Gardens and Community-based Initiatives

The Kumalo de Wet study of the Daggafontein Informal Settlement, reported below, has noted the rural origins and the existence of agricultural training and skills within this community. It is likely that this applies equally to other informal settlements in the area. It was also noted that entrepreneurship at the trading level is well developed in the community with a can-do approach to making a living wherever opportunity appears.

Although the main recommendation was that opportunities of formal employment would present the first and most practical option for the people involved, the

likelihood is great that, given the appropriate opportunity and access to resources, the potential exists to successfully enter the substantial informal fruit and vegetable trading market in Eastern Gauteng. This might be done using certain product grades from the Option 2 output or may be generated in urban gardening or community-based initiatives.

However, limited success has been reported with existing gardening initiatives where small plots are remote from residential areas and relying, in the main part, on the ill and infirm members of the family who are otherwise unable to go out to work. The most viable option, and the substance of the proposal made here, is that the concept of peri-urban small holding development be considered, where the working of an economically viable unit is in the hands of the active members of the family, or consortia of neighbours. The indicators of success for small urban gardening projects were considered to be low.

A further constraint is the capacity of the community (whether as individuals or as groups) to assume long-term responsibility for shared facilities, on the basis that everybody's job is nobody's job. In this regard it will be essential, for the ongoing success of the Option 3 enterprise, that the following be considered:

- Only medium to medium-large size units be established including:
  - 1 ha plots for cultivation by an individual
  - 2 ha plots, for cultivation by up to three individuals, possibly as a family group
  - 4 ha plots, for cultivation by a group of up to 6 persons working as a consortium, and possibly targeting development in time to more formal hydroponic-type systems.

- As this will involve direct agriculture, only unspoilt ground should be used for this option;

- Access to the scheme to be on commercial grounds only and based on a low interest long-term loan recovery programme:

- Training and support infrastructure be established at the outset in the form of a well equipped and staffed extension service, and to be maintained as an essential input requirement throughout the life of the programme;

- Plots be connected to irrigation water mains to supply a minimum of $60m^3$/ha/day;

- Plots be equipped with appropriate irrigation equipment such as dragline or drip irrigation systems;

- Co-operative use of large equipment such as tractors and ploughs to be set up;

- Co-operative marketing systems to be established and maintained until producers are able to take on this aspect themselves.

All of the aforementioned options would be open-field cultivation, generally in a ridged top-soil structure, complete with a manually-controlled drip-irrigation or drag-line systems.

In the Daggafontein community context, the proposal would be to implement the larger community plots only where agricultural activity can take place on a commercial (immediate community need based) basis. However, it should be noted that this option is probably a second-line approach – the ideal solution is still likely to be the creation of employment within a totally sustainable, minimal risk option such as a commercial hydroponics structure, linked to professional farming management and commercial markets.

9.8 PROPOSALS

The development of an irrigation agriculture-based SDI in the Springs/Nigel mine lands corridor, and using BioSURE® treated minewater as proposed, appears to be both technically feasible and economically viable. While this could be entirely accomplished within the domain of existing professionally managed agricultural enterprise, the objective of building in empowerment and entrepreneur development goals raises additional requirements that need to be addressed. These objectives are also feasible and achievable, but with careful planning and appropriate provisions being made for the particular circumstances that apply, so that failure is not built into the programme at the outset.

The following proposals are based on the outcomes of the various studies undertaken in this report:

- The final SDI scheme be sized on the utilisation of 30ML/day treated minewater, being the projected amount that will decant and need to be managed over the long-term once mining operations finally cease in the East Rand Basin. ERWAT water treatment works in the area will be able to sustain the 1:3 dilution currently proposed;

- A commercial mentorship model should be considered as an essential requirement in agricultural entrepreneurship development in the context of this project. To achieve this, both an extensive open land and an intensive hydroponics agri-business enterprise should be set up to form the anchor clients of the SDI scheme. These will provide the technical and economic momentum for job creation and agricultural management training on which the other components of the scheme will critically depend, and should be negotiated as a condition of the enterprises at the outset.

- The scheme would be implemented as a phased programme with an end land use pattern to be determined in detailed studies to follow, although speculative this might feasibly look as follows (Table 9.18):

    - The agri-business component made up as 250 ha extensive and 50 ha of intensive mixed fruit, flower and vegetable production (assuming a 50:50 greenhouse:shadecloth mix). This would utilize 8ML/day treated water, generate a net farming income of about R14 million and create around 400 permanent jobs.

    - The farming entrepreneur development programme (EDP) to be based on a similar area allocation with 25 ha extensive, and 2 ha intensive plots, providing access initially to 35 in the EDP. Water consumption would be similar, while both income and employment numbers might be lower initially. A realistic assumption of a net farming income achieved initially of R7million and 300 permanent jobs has been assumed. This could improve with time and experience

- An area of 250 ha allocated for medium to large-scale urban garden enterprises made up of 1-4 ha plots (possibly 40x1; 20x2; 15x4). This will make provision for 75 garden operators or consortia, and will likely create an additional 250 seasonal jobs and utilize 14 Mℓ treated water. The net income is difficult to compute but has been assumed at R20-30 000/ha depending on production and management practice, and value adding opportunities in the informal sector.

Table 9.18: Summary of water, land use and job creation potential in a hypothetical allocation of resources in the proposed Springs/Nigel SDI in Eastern Ekurhuleni.

	Area (ha)	Water Usage (ML/day)	Owner/operators	Jobs	Net Farm Income (R)
Agri-business	300	8	3	400	14
Farming EDP	300	8	35	300	7
Urban garden	250	14	75	250	5
Totals	850	30	113	950	26

Without a final allocation of the land into the various proposed sub-units, it is not possible to develop detailed financial models – and indeed, this has to be the subject of a comprehensive business plan as the next stage in the programme (noted below). However, based on the individual financial calculations for each of the land-use units (detailed above), it is possible to conclude that the enterprises would indeed be financially viable, and that the Return on Capital calculations would be positive.

It must be noted however that the financial returns for some of the units – especially those where community job creation is the primary goal – may well be lower than those for a similar fully commercial unit. In these instances, the total economic benefit, and not just pure financial returns, would also need to be taken into account as the measure of success.

10. SOCIAL DYNAMICS OF INFORMAL SETTLEMENT COMMUNITIES LIVING ADJACENT TO THE SPRINGS-NIGEL CORRIDOR

Sibongiseni Kumalo & Chris de Wet
Department of Anthropology, Rhodes University, Grahamstown

10.1 INTRODUCTION

In many ways South Africa may seem to be the envy of the rest of the continent, having made an almost violence-free transition to democracy, and ranking as one of the leading emerging economies, with a relatively strong currency and low inflation rate. However, South Africa is currently struggling with the impact of three problems which seem to reinforce each other in a kind of vicious cycle. Firstly, it has a population short on skills, and a disturbingly high rate of unemployment (with the most recent census suggesting a figure of around 40 per cent). Secondly, it has one of the highest HIV/AIDS rates in the world, which threatens to knock out a significant proportion of the productive generation. Thirdly, it is a semi-arid country, with something like two-thirds of its surface area receiving 500mm of rain per year, which places significant limitations on the scope of land reform in South Africa – whether as a vehicle of social justice, or as a means to increasing livelihoods – as well as on health, on urban quality of life, and on industrial development. Any development strategy which is to succeed, needs to break through this vicious cycle, and to do so it needs to impact on at least two of these three problems, in order to set up a cumulative, and positive, counteractive process.

While skills may be the human resource in most short supply in post-1994 South Africa, water is our scarcest natural resource – not only for human consumption, but also because both agricultural and industrial development are heavily dependent upon water. Gauteng is the industrial and financial hub of southern Africa, and it is only realistic to expect sustained in-migration into the region. The Lesotho Highlands Water Project is not going to be able to supply all the needs of the province, and the issue of access to water thus becomes all the more urgent.

This report examines the possibility of initiating such a positive process through considering ways in which an enhanced water supply could help improve both food security as well as household income levels in Gauteng Province. The Rhodes BioSURE Process and Water Beneficiation technology, which is at the centre of this overall project, and which is discussed in detail in its other components, will be able to clean substantial amounts of previously polluted mine water as well as sewage water – and thereby to make it available for development purposes, at community level, and possibly also for larger scale ventures.

But natural resources, whether in original or recycled form, are only one side of the development equation. Technology only exists and is utilised – well or poorly – within a human context, and development projects stand or fall by the way in which the technological and the human components are coordinated. If the socio-economic context is inappropriate to the technology being introduced and its economic correlates, the technology will not achieve what its designers intended, 'receiving' communities and environments will be disrupted, and a lot of time and money will have been wasted. Accordingly, a settlement has been selected as a 'target community', in which to assess the viability of such 'new water' development initiatives. The informal shack settlement of Daggafontein, consisting of about 800 households, is situated in the Springs area of the Ekurhuleni Metropolitan Council of the Gauteng Province of South Africa, close to the ANCOR sewerage works, and in the vicinity of the Grootvlei Mine.

The Agricultural and Wastewater Beneficiation component (Mellville and Leucona, 2003) of this overall project has considered several possible developmental uses of the cleansed water that would become available as a result of the Rhodes BioSURE and Water Beneficiation technology being applied to mines in the Springs area, notably Grootvlei Mine. It recommends that a hydroponic Atriplex system be implemented. For illustrative purposes, utilising 10 Mℓ of treated Grootvlei water per day, the hydroponic Atriplex system could be applied over an area of 150 hectares, allowing for:

1) the cultivation of 'old man salt bush', which would purify the polluted mine water before it is returned to the Blesbokspruit. The leaves of the bush could also be sold for fodder.
2) Some 83 hectares of vegetable cultivation under hydroponics, under a medium tech shade-cloth hydroponic system. This should allow for the creation of some 200 jobs, at an estimated income of R5013 per person per month .

It is estimated (P. Rose, personal communication, October 2003) that when the water purification technology is functioning at optimal efficiency, some 50 Mℓ of mine water would become available on a daily basis. This increases the job creation potential to something like 1000 jobs in the vicinity of Grootvlei Mine.

This report situates itself in relation to the recommendation to adopt the medium tech hydroponic Atriplex system. It will attempt to assess what the socio-economic requirements of such small scale, relatively high tech cultivation are, and whether the inhabitants of the settlement of Daggafontein possess the necessary characteristics and entrepreneurial qualities to make a success of such an initiative.

10.2 IS URBAN AGRICULTURE THE 'GOLDEN BULLET' FOR THE DEVELOPMENT OF POOR URBAN COMMUNITIES?

A number of scholars and development specialists have looked to urban agriculture as the key to combating urban poverty and to unlocking entrepreneurial potential in poor urban settlements. There are reports of substantial numbers of households practicing urban cultivation, whether in their own gardens, on plots outside town, or in community gardens, in Dar es Salaam (Tripp, 1997), Maseru (Phororo, 1996), and in Cape Town (Karaan and Mohamed, 1998). However, when we look more closely at the situation on the ground, things do not seem all that positive. Webb, in his doctoral thesis on urban gardening, surveys the literature: he finds that most of the studies are vague when it comes to hard figures about actual inputs, production/yields, income generation and nutritional impact, and that "claims for 'UA' pale against empirical findings drawn from the Eastern Cape"(Webb, 1996: 267), with urban agriculture playing " only a very small role for the vast majority of [his] informants" (Webb, 1996: 273). A study in Cape Town in 1989 found that " households with gardens were producing less than 1 per cent of the vegetable requirements of the HSL [household subsistence level]", and a study by Slater in 1993 documented " the limited contribution of vegetable production to household income or income substitution" (Slater, 2001: 636). In their study of Cape Town townships, Kareen and Mohamed found that " it appears that there are more gardeners producing a surplus and generating an income, *to a greater or lesser degree* [my emphasis], than there are those merely gardening for home consumption" (1998:77). They state that these gardeners are not aware of all the actual production costs, such as water, labour and equipment, and that " Despite inadequate costing, most of those who sell to their neighbours on an ad hoc basis believe that it is profitable and worth the effort". Similarly, Webb (1996: 274) finds that " Low-income informants viewed their activity as a means of increasing welfare (a view disputed by the findings)".

The constraints are all too predictable: shortages of critical resources such as land, capital, water, seeds, expertise, fertiliser and insecticides, markets. If one is to break into markets larger than the neighbourhood, it is imperative to produce high quality vegetables and get them to market on time and in top condition. While there are widely differing claims about the extent to which urban agriculture is practised across the continent, it appears that we do not have much actual detail as to the economic value of urban agriculture. Where such statistics (e.g. Webb, 1996) are available, they strongly suggest that it yields only very limited returns in terms of household diet or budget. People seem locked into a vicious cycle where low resource availability leads to low inputs and investment, which leads to low yields and incomes, which leads to low rates of cultivation. Our findings from the research on which this report is based indicate that this situation is echoed in the community garden at Daggafontein. Urban agriculture – as currently practiced under present conditions in South Africa – would seem to have only very limited potential to combat poverty and to unlock local enterprise in poor urban areas. However, in spite of these limitations, there are those people who do make the effort to cultivate, and to market their goods. While the majority of Webb's sample who actually cultivated had rural backgrounds, and while the studies cited above in Cape Town (Karaam and Mohamed, 1998) and Dar es Salaam (Tripp, 1996) suggest that the majority of urban cultivators were women, Webb cautions us that we need to be careful of seeking a socio-economic stereotype of the prototypical urban cultivator. One can just as easily find urbanised, or high income (as in Lusaka – Webb, 1996: 126), or male, cultivators. But it would seem that what these urban cultivators do have in common is a kind of entrepreneurial spirit; and it is that spirit that must be identified and assessed in places like Daggafontein if the urban agriculture project is to succeed.

10.3 IS HYDROPONICS LIKELY TO BE ANY MORE SUCCESSFUL THAN CURRENT URBAN GARDENING PRACTICES?

The literature on urban agriculture seems to be telling us that we will not make any progress unless we can break through the 'cycle of lows' outlined above, But what might happen if we were able to transform that cycle of lows into a 'cycle of highs', with high initial capital, adequate land, high inputs, high level management and extension services, high yields, high income from participation in higher level markets – such as is suggested in the hydroponics strategy put forward by Melville and Leucona (2003). Hydroponic cultivation of vegetables is capable of providing very high yields, and correspondingly high incomes, off small pieces of land. Thus, Melville and Leocona estimate that medium tech shade-cloth hydroponic cultivation could produce an annual net income of R150 000.00 per hectare per year. What are the advantages and disadvantages of a hydroponic approach, what kind of socio-economic profile does it require of its participants, and is it sustainable in the long run?

The details of the hydroponic approach will not be discussed here, as Mellville and Leucona do so in their report. We will instead briefly define hydroponics and outline some of its advantages and disadvantages, in order to identify the necessary requirements for it to be done successfully – and then to be able to interrogate our findings on the socio-economic situation in Daggafontein, and to assess whether the inhabitants of Daggafontein are appropriately placed in this regard. For brevity and clarity, and because at this point we are concerned with exposition rather than argument, we here provide a lengthy quote from a document on the website of the Agricultural Research Council of South Africa.

Hydroponics may be defined as "a system where plants are grown in growth media other than natural soil. All the nutrients are dissolved in the irrigation water and are supplied on a regular basis to plants. In South Africa, hydroponic vegetable production is almost always done under protection.

Advantages of hydroponic vegetable production include:

- hydroponically produced vegetables can be of high quality and need little washing
- Soil preparation and weeding is reduced or eliminated
- It is possible to produce very high yields of vegetables on a small area because an optimal environment for plant growth is created. All the nutrients and water that the plants need, are available at all times
- One does not need good soil to grow vegetables
- Water is used efficiently
- Pollution of soil with unused nutrients is greatly reduced

The disadvantages of hydroponics include that:

- Hydroponic production is management, capital and labour intensive
- A high level of expertise is required
- Daily attention is necessary
- Specially formulated, soluble nutrients must always be used
- Pests and diseases remain a big risk
- Finding a market can be a problem"

(www.arc.agric.za/institutes/roodeplaat/main/topprojects; May 2003).

Hydroponic vegetable production thus requires high levels of initial capital, agricultural expertise and management (including financial) skills; a committed and trained labour force; market linkages and the ability to get the product to market on time; and an ongoing supply of clean water. The capital to set up a medium tech hydroponic project at Daggafontein would presumably be put up by a development funding grant, although any future costs, such as new equipment or replacement of old equipment, ongoing purchases of seedlings, fertiliser, insecticide, etc. the costs of getting crops to markets, etc. would presumably have to be borne by the project.

Agricultural expertise and training might initially also be funded and secured by the grant, but would in future have to be borne by the project, which is presumably going to have to invest in training on an ongoing basis. If water is increasingly to be paid for by consumers, it is quite likely that in future the project at Daggafontein will have to pay for the clean water it needs to sustain the hydroponic initiative. All of this calls for effective, entrepreneurial, fiscally sound and strong management, both at project level and at shade net and individual farmer level. While the Mine might initially supply a manager to help the project and its participants settle in and find its feet, to be sustainable in the longer term, the project is going to have to provide its own managers and handle its own relations with wider institutions, such as local government, suppliers, markets, and Inland Revenue. It will also need to keep its labour force committed, disciplined, trained, productive and unselfish enough to cooperate with each other, share information, help in crises, etc.

Before considering our research findings, and considering whether Daggafontein is likely to be able to meet the above requirements for successful hydroponics, we will briefly outline the research methodology and chronology followed in obtaining the information on which this report is based.

10.4 METHODOLOGY AND CHRONOLOGY OF RESEARCH

1. A project research proposal was prepared and submitted, which constituted Sub-Deliverable 1 of Deliverable 2 of Part 4 of the overall project. This proposal was submitted at the Group 4 Technical Sub-Committee Meeting held at Ancor on the 2nd of June 2003 (see Appendix One).

2. Mr Kumalo's Anthropology Master's thesis proposal was prepared and submitted at the end of May 2003 to the Humanities Degrees Committee of Rhodes University, which sat on 23 July 2003 and approved the proposal.

3. Mr Kumalo undertook his first field trip to the research area, spending a period of four weeks, from the 1st to the 27th of June 2003, residing at ANCOR, and going to the Daggafontein settlement every day. The members of Daggafontein settlement are overwhelmingly either Xhosa or Zulu speaking. As Mr Kumalo is a first language Zulu speaker, as Xhosa and Zulu are mutually intelligible, he had no difficulty in communicating with people. He hired a research assistant from the Daggafontein community to work with him and to introduce him to the people. This first research trip, which entailed the necessary steps required to settle into the situation, involved:

    - Obtaining permission from the Ekurhuleni Municipality to work in the Daggafontein settlement. This permission was granted on condition that a research report will be made available to the Department of Health and Social Development of the Ekurhuleni Metropolitan Municipality, in order to feed into its Poverty Alleviation Programme. The letter of permission was faxed to the ANCOR office on the 11th of June 2003.

- The gathering of brief life histories/biographical sketches from 80 individuals in the Daggafontein community. Information was obtained about the area of origin of the respondents, their education, migration patterns and employment history, and whether they had any agricultural experience.

- Two visits to the local community garden, during which 13 interviews were carried out.

- Attending church services at the Daggafontein Methodist Church on Sundays.

- Discussions with a number of spaza shop owners in Daggafontein.

- Discussions with some members of Street Committees and the leadership structure in Daggafontein.

Mr Kumalo then came back to Grahamstown for the period of 28 June to 12 July 2003, to write up and discuss his initial findings with Prof de Wet. On the strength of these findings, they drew up a detailed socio-economic survey/questionnaire for implementation during Mr Kumalo's second field trip. A draft of this questionnaire was presented and discussed at a meeting of the Group 4 Technical Sub-Committee, held at the Johannesburg offices of PHD on 8 July 2003, after which the questionnaire was finalised (A copy is appended to this report, as Appendix Two).

Mr Kumalo then spent the period of 14 July to 16 August 2003 back at ANCOR, administering the questionnaire to 60 of the 80 households from which he had obtained life histories during his first field trip. He attended church services, and also held discussions with members of the Daggafontein leadership structure and members of the Ekurhuleni municipality. He used the same research assistant as during his first research trip. He returned to Grahamstown on 17 August, to process and analyse the questionnaires, and to work with Prof de Wet on this Final Report.

10.5 RESEARCH FINDINGS

10.5.1 A General Overview Of The Daggafontein Community

10.5.1.1 The Nature of the Community

Daggafontein (see Map, Figure 6.1) is an informal settlement of more than 800 households. It is situated close to the ANCOR sewerage works and in the vicinity of the Grootvlei gold mine. There are accounts of people living in Daggafontein since the 1960s. Members of the community of Daggafontein have both rural and urban socio-economic characteristics. Almost all people interviewed have a house in the rural area from which they originate, as well as one in Daggafontein, and there is a movement of people and resources between the rural areas and Daggafontein. The majority of people interviewed would like to retire to the rural areas. Most people have come to the Springs area in search of a job, and Daggafontein has provided a convenient residential area in terms of access and affordability. There is a well-established system of social networks and connections within this settlement, with a large number of people having come to Daggafontein through connections such as relatives, a spouse, friends, church links, work mates, etc.

As elsewhere in Africa, urban growth has brought with it a multitude of problems, such as unemployment, deteriorating infrastructure, overcrowding and environmental degradation. (Cheru, 2002). The settlement is without water and electricity, with more than 800 households sharing two public taps. Rubbish collection is coordinated by Zincor. Despite the fact that there is no electricity, a considerable number of people own a number of electrical appliances, such as stoves, televisions and washing machines, in anticipation of the day that services are provided to the settlement. This suggests both a measure of disposable income, as well as possible signs of permanence, with people looking to make their life more comfortable in Daggafontein, as well as to acquire what may be seen as status-conferring consumer goods.

10.5.1.2 Administration.

Daggafontein falls under Ward 50 of the Ekurhuleni Municipality, under Councillor Fourie (pseudonym). The ward structure is made up of: the Councillor, Secretary, and the Ward Committee (*see Organogram 1).*

The Ward Committee consists of ten sectors namely:

- Religious sector, which looks to the moral fabric of the society.
- Business sector, which focuses on business-related issues.
- Youth sector, which deals with youth development and youth-linked projects.
- Women's sector, which deals with gender issues and women's projects
- Sector for the Disabled, which encourages arts, culture and handwork among this group.
- Non-Governmental Organisations sector, which focuses on community development.
- Community-Based Organisations sector, which deals with the civic organisations and with dispute resolution.
- Education sector, which deals with education related matters.
- Sports and Culture sector, which promotes and deals with sports issues.
- Health and Welfare sector, which is concerned with health matters.

The Ward Committees are voluntary (i.e. non-remuneratory) and advisory structures that provide the people with the means to make an input towards developmental local government, for the integrated delivery of services to the residents. The Ward Committee aims to communicate information about municipality activities to residents of the geographical area under Ward 50, to facilitate the implementation of all municipality projects in the Ward area, and to monitor the behaviour and performance of project employees. Other functions of the Ward Committee assisting with the resolution of problems within the ward and between wards, as well as promoting local economic development activities.

The Ward Committee is supposed to meet at least once a month, as per Municipality resolution. The failure of the Ward 50 Committee to do this is due to the unavailability of some members for meetings due to their work commitments.

The Daggafontein Street Committee is linked up to the Ward Committee, with one Street Committee Member serving as a member of the Ward Committee. The Street Committee focuses more on localised and day-to-day domestic issues. There are some tensions within the Street Committee, with various members jockeying for influence, and with some divisions apparent along generational lines.

10.5.1.3 Life Histories/Biographical Sketches: a Snapshot of the Community

Eighty brief life histories were collected with a view to finding out some basic information about residents, such as the area of origin of the respondents, their education, migration patterns and employment history, and whether they had any agricultural experience. These brief sketches were aimed at giving us an idea of whether the person seemed more rural or urban in orientation, i.e. what their commitment to a place such as Daggafontein is likely to be, and whether they have any skills or experience that might be appropriate to an urban agriculture project. The life histories were also intended to give us a general picture of the community, to enable us to draw up a more detailed socio-economic questionnaire for the second period of field research.

Case Study A: Mr Khaba (Pseudonym)

Mr Khaba was born in KwaZulu-Natal at Msinga near Pomeroy in the 1960s, one of eight siblings. There were four boys and four girls. The rest of his siblings are all employed in KwaZulu-Natal and are not married yet. Neither he nor his siblings had a chance to go to school when he was young, as they were busy working at home and looking after the livestock. At that time those children who were sent to school in other families were seen as 'whites' and were seen as trying to appear superior to the rest of the children in the village. Being educated at that time meant that a person was seen as being a sissy and not doing any hard work. Men especially were supposed to work hard in the fields. Girls on the other hand were not taken to school because there was a fear that they would get married, so educating them was seen as a waste of money. He went from Msinga to live in Carletonville in Johannesburg. He worked there for a while and then in 1995 he moved to work at Springs, where he worked in Payneville. He came to Daggafontein after losing that job, as it was convenient because there is no need for him to pay rent. He is currently in his fifth year of working for the Super Cleaners Company in Springs. He got married after his first job in Johannesburg. He now has five children, who are all at school. The first-born is a thirteen-year-old girl. His wife and children are all at home in Msinga. He attends the Jerusalem Church when he is at home. He does not get much time to go to church in Daggafontein, as during weekends he is doing the household chores such as washing and cleaning the house and the premises.

Discussions were open-ended, so as to give the respondents a chance to focus more on what they wanted to talk about. The following account, that of Mr Shoba, is different in emphasis from that of Mr Khaba (above), who talked more about the school education that he did not get a chance to obtain. Mr Shoba, however, focused more on his previous jobs and experiences because he is currently unemployed and is looking for employment. He seemed to be trying to 'sell' himself to the researcher, possibly hoping that something might come up.

Case Study B: Mr Shoba (Pseudonym)

Mr Shoba is about 40 years old, and is originally from Pholokwane in Pietersburg. He was one of four children, two boys and two girls. They all went to school up to the primary level. His sisters are all married and unemployed in Pholokwane. He and his brother are also married. His wife and four children, who are all at school, are at home in Pholokwane. Mr Shoba does not go to church. This is because his father was a sangoma (i.e. diviner) and was against the church, and so they ended up not going to church as children. His home village is Nebo near Pholokwane. The first place he worked at was Goedgedag (Pholokwane); he worked there for some time and then went to work at Kromdraai (Pholokwane) as a truck driver. He was transferred to Mohlalotwane (Pholokwane). After he was retrenched he came to look for a job at Springs. He worked on a farm and was staying at KwaThema in a hostel. He subsequently moved to Makhohloza (Springs), working on a farm. After losing that job, he came in January 2003 to stay in Daggafontein with his brother who was already living there. He is still looking for a job. He is ready to relocate to anywhere he gets a job. He states that he is not permanent here. He is only here because he is looking for a job. The job he is best equipped for, is that of a truck driver. In Daggafontein he stays with his brother. The shack they live in is not theirs; it actually belongs to a friend of theirs who offered it to them. His brother is currently at home (in Pholokwane), visiting; he is also not employed. Their wives nevertheless are employed back home, which is what keeps them going.

Case Study C: Mrs Simamane (Pseudonym)

Mrs Simamane, in her early thirties, was born in Swaziland and grew up there until she got married to Mr Simamane who was then based in Swaziland. After getting married they moved to the Eastern Cape where Mr Simamane is originally from. She came to Gauteng with her husband, and was seeking employment. Her husband was already employed in Gauteng. Mrs Simamane is the fifth of six children in her family. The other five are still in Swaziland. She went to school up to Standard Ten (Form 12) in Swaziland. She came to Springs in 1995 and has been in Daggafontein for about eight years now. She attends the Methodist Church, and has been a member of this church ever since she was young. She has a position in the church at Daggafontein, as the Leader and the Secretary for the women. She works as a social health representative, for the Ekurhuleni Municipality. She works closely with the government Department of Health. She is also involved in the community gardens as the Coordinator's assistant.

Case Study D: Mrs Falo (Pseudonym)

She was born at Lydenburg in Mpumalanga province at Mashishini village. She is the second of nine children: five boys and four girls. She feels that her parents brought them all up well. She and her sister, as the older children, never went to school, but had to give a chance to their younger siblings. Her boyfriend whom she met ten years ago is working in a firm next to the Daggafontein settlement. She attends the Zion Catholic Church, which has a presence in the settlement. The only employment she has ever had was to work as a domestic worker back home.

10.5.1.4 The Community Garden

Daggafontein has access to a community garden, which was visited by Mr Kumalo during his first field trip. It is right next to Vitanova Hospital and is about 150m² in extent. Social workers suggested that the community should start a community garden and sell the vegetables to the nearby hospitals; they had evidently obtained the support of local hospitals such as SANEL, Struisbelt and Vitanova hospital, which has made a piece of land available to the community.

After the community had been given the garden, basic training was offered. Not everyone in the community attended, as not everyone was interested. Not everyone has followed the guidelines given during training.

Initially, people were allocated their garden plots by the social workers, although this is now done by the Coordinator. Seeds are given free of charge via the Community Garden Coordinator, who distributes them to the people. Some of the gardeners are concerned that the administration of the gardening project should be handled by the social workers, as they do not fully trust the Coordinator in this regard.

Zincor provided the community with tools such as wheel barrows, spades and forks; while this is highly appreciated, people still need to share tools. The tools are supposed to be locked in a tool room, which is at the community garden; however, people take them (tools) home. This causes unhappiness when someone wants to use a specific tool and it is not there. The fencing of the garden for security reasons was the initiative of the social workers, to prevent theft from the hospital; this fence now separates the garden from the hospital.

A plastic water tank was also provided at the social workers' initiative. An agreement was reached that the hospital will pump water to the tank every time people come to work in the garden. It is a small tank, but is still better than nothing, and people hope that another will be provided, as promised, by the Department of Welfare and the Department of Agriculture.

People plant vegetables such as beetroot, carrots, tomatoes, cabbage, spinach, etc. The social workers have not yet taken the vegetables to the hospital as they had promised. This could be for a number of reasons, such as that gardeners are not following the techniques they were taught, or that the quality and the quantity of the vegetables is not yet up to standard, or perhaps that people are expecting too much too soon, as it has only been a year since the gardens started working.

The community Garden Committee invited an agricultural extension officer to come and assist them with training, as they felt that they lacked the necessary agricultural knowledge, such as what sort of fertilizers they should use. Some members of the community garden felt that they benefited a lot from his assistance. However, some members dropped out because they could not keep up with what the agricultural extension officer had instructed them to do. The following case is that of Mrs Phulo, who dropped out of the community garden.

Case Study E: Mrs Phulo (Pseudonym)

She joined the garden in 2001, at the very beginning of gardening in Daggafontein. She felt the need to join a community garden, to get money from selling vegetables. She would also eat some of the vegetables and so would not have gone to bed hungry. At that time there was an agricultural extension officer who was teaching them how to cultivate. He showed videos. Some people were not satisfied, because they said that to watch some thing on the TV is not the same as actually doing it. Most people wanted to learn by doing, and not in a classroom setting. One of the things they were taught was to dig holes about three feet deep for each bed. In these, they were supposed to throw all sorts of decomposing items such as leaves and pieces of wood as well as grass. Mrs. Phulo dug three such holes. She then became very ill, and gives this as the reason why she stopped going to the garden. The people who came after her utilised those holes that she had prepared. Mrs. Phulo suspects that digging those holes was the cause of her sickness, as she says that her body became very painful. Another issue that Mrs Phulo raises with regard to people stopping going to the garden is that of distance. The garden is 'very far' from where people stay. Mrs. Phulo complains about the long distance that the people have to walk when going to the garden. It seems as if she was not going to continue with gardening even if she did not get sick. She stresses that they used to be burned by the sun going there in the morning and encounter rain and thunderstorms when coming back home. She says that these are the things that one cannot tolerate. When asked if there are any taxis going to the hospital she replied that 'taxis don't go there. Even if they were to go there, the people will still need to pay, which is also a problem, because people don't have money'.

Mrs Mbodlela (below) joined the garden last year (2002) and has a different view of gardening; she seems very optimistic. The only real problem for her so far is that the tank is far from her plot, which means she has to walk a long distance, and this is a problem because she is too old for carrying buckets of water. Other interviewees had the same problem and think that installing water pipes could be a solution.

Case Study F: Mrs Mbodlela (Pseudonym)

She has been involved in gardening since a very young age at home (Qwaqwa). Now she goes to work in the garden because she has no food. She joined the gardens last year (2002). She thinks that most people don't do any gardening out of laziness. People just don't like gardening; accordingly it will be difficult to attract them to join the community garden. Mrs Mbodlela is not certain as to whether they will be able to sell produce to the hospitals as they cannot yet meet the demands (quantity) of the market. She feels that they have enough tools, although they still share some – but this is not a problem. Should more people suddenly develop an interest in gardening, some *members may have to give away some of their garden space to accommodate them. That will not be a problem, as everyone will still get something from the community garden. Many of the problems will be solved once the water is easily accessible to everyone in the garden. She would be grateful if the agricultural extension officer could come to give them some more lessons.*

10.5.1.5 Local Enterprise

There are quite a large number of business activities in Daggafontein; while most of them are at a small scale, the entrepreneurs are very enthusiastic about their business endeavours. These businesses vary from spaza shops, to sheebens, bottle stores, phone shops, to individuals selling fruit and sweets next to the road. Although the community garden was the social workers' initiative, it still suggests that the community has entrepreneurial potential and energy as a few of the gardeners sell some of their produce. A number of individuals would like to open their own spaza shops, but cannot do so because of a lack of start up capital.

The case study that follows is that of Mr Zepe, makes a living out of it. He also employs people to assist him in his garden, which he uses to supply his shop with fresh vegetables. The case gives brief background information on this small businessman.

Case Study G: Mr Zepe (Pseudonym)

Mr Zepe is 31 years old, and is originally from Sekukuneland in the former Lebowa. He is married with three children, and has stayed in Daggafontein for 11 years. He goes home every month to visit his parents, his brother and (his brother's) children. They all visit him about three times a year. He has some cultivation experience, which he learned from his father. Both his parents are pensioners and stay with his younger brother. He regards Daggafontein as his home. He makes it clear that he will stay in Daggafontein for as long as he makes money. He did not complete high school, dropping out in Grade 10. He is the first-born and he had to leave school and go and look for a job so that he could support his younger siblings. He could not find a job as soon as he had hoped; so he then went to a college to study business administration, and obtained a certificate. He then started selling sweets from home. He could not find a decent job, until he went to a college to study electrical engineering, which he was also interested in. He obtained another certificate, after which he got a job at Befcan, as an electrician. He continued to sell sweets and vegetables from his room. Six years later he got married, in 1997. His friend lent him money to buy a car, after which he quit his formal job. He then focused solely on expanding his spaza shop. He moved to Daggafontein because he saw a great opportunity to make money there. The business went very well, and he paid back the loan from his friend and was sending his siblings to school. At that time he was also supporting his younger brother who was at university; he is now working at Grootvlei Mine, and doing very well. Seeing that his car was in demand as a taxi, he bought another one. He uses his two cars as taxis as the ordinary taxis (kombis) can't take lots of luggage when transporting people. He takes people as far afield as the Eastern Cape.

He complains that almost all his neighbours have opened their own spaza shops. He nevertheless still believes that he is more experienced than they are and that therefore he can still make it. Mr Zepe is also heavily involved in the community garden as the chairperson. He usually hires casual workers to work in his garden in which he plants maize, vegetables, beans and potatoes. His garden supplies his shop with almost all its vegetables. He hopes that if things go well he will be able to buy a truck and open a hardware shop back home, where he will specialise in electrical appliances. He also hopes that, should formal housing be provided in Daggafontein, he will also benefit in that he will be installing electricity to those houses.

Some of the businesses are seen as a hazard by members of the community. One such example concerns a notorious shebeen where a number of people have been killed in the fights that often occur. This came out strongly in one church service where people were praying about a particular shebeen, that it would stop selling liquor at night. One of the street committee members commented that he has never attended a funeral of a 'shebeen queen', yet people die in those shebeens. He was voicing his anger about the existence of the shebeens in the settlement. Another respondent commented that even the 'traditional beer' sold there contains toxic elements such as battery powder or battery acid. (This can, however, not be taken as a fact). The point nevertheless is that some of the businesses in the area are seen as bad for the whole community. But, as Mr Zepe pointed out, they will remain in Daggafontein for as long there is money to be made there.

As mentioned before, most businesses are small, but their owners want to expand them. The following case concerns Ms Joka who came to Daggafontein following a boyfriend who got a job in a nearby firm.

Case Study H: Ms Joka (Pseudonym)

She was born at Ermelo and came to Duduza (a township near Springs) looking for a job. She worked as a domestic worker and she bought herself a house; she then moved to Daggafontein in 1994, following her boyfriend, and again she got a job as a domestic worker. The house in Duduza is left in the care of her younger son, whom she visits weekly. She has been running a spaza shop since 2001. This she started to combat poverty. She says she would have joined the people at the community garden, except for the fact that the garden takes too long to generate profit, and that the risks are too high in agriculture. She wants to expand her business, but still needs the necessary license. She heard that licenses are obtainable from the town council but she is scared to go there. She started the spaza business a long time ago. While in Duduza she had a spaza shop until she was robbed and stopped running it. Her shack in Daggafontein is strategically positioned for people to buy things as they pass. She seems to be a very busy woman with good people skills. Most people just come to her for a chat even if they don't buy anything. She is unable to go to the community garden because she is not well, and gets a government disability grant. She knows that the garden is too far and people complain about the water tank being far away from most plots. She does not anticipate being employed in her life, but she looks forward to expanding her shack in the near future so that she will be able to store the supplies for her shop in the shack. For this she would rather ask for her boyfriend to take out a loan for her. She needs about R 2000-00.

10.5.2 A SELECTIVE STATISTICAL PORTRAIT OF THE DAGGAFONTEIN COMMUNITY

Information for this section was obtained by administering the questionnaire discussed earlier (see Section 10.4) to 60 households during Mr Kumalo's second field trip.

10.5.2.1 Household Composition

Table 10.1: Household Members Living in Daggafontein (N= 60)

Adults	**Children**	**Total**
163	82	245
Average 2.71	**Average** 1.36	**Average** 4.08

On average, in each household the at-home-population thus consists of:

i) 2.71 adults
ii) 1.36 children
iii) 4.08 people per household

Household Members Away.

The total number of members of the sampled 60 households away from Daggafontein is 264, giving an average of 4.4 people away per household. The average number of adults away from Daggafontein is 3.4 (1.51 males; 1.88 females), and the average number of children away per household is 1.

There are household members away who are in rural and in urban areas. The average number of adult males away in urban areas per household is 0.65, as against 0.82 females. The corresponding figures for adults away in rural areas are 0.87 males and 1.07 females respectively. Children who are away are overwhelmingly (87%) in the rural areas.

Table 10.2: Household Members Away by Gender

Adults		**Children**	
Male 39	Urban	Male 4	Urban
Male 52	Rural	Male 25	Rural
Female 49	Urban	Female 4	Urban
Female 64	Rural	Female 27	Rural
Total 204		**Total 60**	

Table 10.3a: Household Members (Adults) Away by Gender, Age, Education, Occupation and where they are living.

Males		**Urban**	**Average Educ.**	**Females**		**Urban**	**Aver Educ**
Rural	**Ave. Educ**			**Rural**	**Average Educ**		
17 Employed	Grade 7	24 Employed	Grade 8	6 Employed	Grade 8	18 Employed	Grade 9
35 Unemployed	Grade 6	15 Unemployed	Grade 7	58 Unemployed	Grade 5	31 Unemployed	Grade 7
52		**39**		**64**		**49**	
Average Age 39yrs		Average Age 35yrs	**Total** Male Average 37.2 yrs	Average Age 58 yrs		Average Age 36 yrs	**Total** Female Average Age 40.8 yrs

As is to be expected, the employment rate is higher in the urban areas, as is this is where most of the economic opportunities are to be found, and the employment rate is higher among males than females. People in the urban areas are slightly better educated than their rural counterparts.

Table 10.3b: Household Members (Children) Away by Gender, Age, Education, and where they are living.

Males		**Urban**	**Average Educ.**	**Females**		**Urban**	**Aver Educ**
Rural	**Ave. Educ**			**Rural**	**Average Educ**		
21 School	Grade 6	4 School	Grade 6	21 School	Grade 4	1 school	Grade 8
4 Not at School	_	_		6 Not at School	_	3 Not at School	_
25		**4**		**27**		**4**	
Average Age 10.8yrs		Average Age 12yrs	**Total** Male Average Age 11yrs	Average Age 9.4 yrs		Average Age 7 yrs	**Total** Average Female Age 9.1yrs

The children are too young to be able to make any general comments about their education levels, but, as mentioned above, they are overwhelmingly in the rural areas –presumably with their unemployed parents.

Table 10.4: Total Household Composition

	Members in Daggafontein	**Members Away**	Total
Adults	2.71	3.45	**6.16**
Children	1.36	1.00	**2.36**
Total	**4.07**	**4.45**	**8.52**

Of adults, some 44 per cent are residing in Daggafontein, with a corresponding figure of 58 per cent for children. The average total household size is about 8.5 people. This following case study is an example of a fairly typical household, with members in

Daggafontein, at home in the rural areas, and in other urban areas. It also illustrates what these members are doing.

Case Study I: Mrs Shezi (Pseudonym)

Mrs Shezi is 45 years old and has stayed in Daggafontein for about fifteen years now. She is married to Phillip Shezi who is six years younger than her. Mrs Shezi stays with her husband and two granddaughters who go to school at Nuffield and at Springs, as well as four other household members in Daggafontein. The members of her natal home are in the Durban area. They all visit once a year. She does not have any resources back home. Her granddaughters go home three times a year during the school vacation. They are still too young to go home on their own, so she usually accompanies them. Even though she visits home, she thinks that Daggafontein is her home where she does most of her things. From her life history it appears that she used to be highly involved in development issues at Daggafontein. She was on the school committee, garden committee and ward committee. She is no longer involved in such things because she became sick and she suspects that she was bewitched by someone in the area. She was born near KwaNongoma in KwaZulu-Natal, one of 13 children. She studied up to Grade 8, but then had to drop out of school due to family problems. In KwaNongoma they stayed at a mission station. They then moved to KwaMashu township in Durban. Her father passed away while they were at KwaNongoma, and after a number of years her (Mrs Shezi's) mother got married again, which is why they moved to Durban. The reason she came to Gauteng was to come and stay with a friend of her mother's who had just lost her husband and who had no children. She says she was still young when she came. After some time she started looking for a job, as she was not schooling. She eventually found a job at Springs at Pick 'n Pay. She worked there for quite some time and then she got another job at Nedbank as a cleaner, where she worked for a long time before she moved again to work at Boksburg. There she was working for a doctor as an assistant of some sort in the surgery. The reason she kept on moving around was that she was looking for better pay and good working conditions. That was her last job as she became very ill. She was hospitalised for three months, and she did not get any better until her brother came to fetch her to Durban. She was taken to a traditional healer: she then got better and came back to Springs. By then she had married and they were staying in a flat in town. Since she was out of work they could not afford to pay the rent. She also had two children (a boy and a girl) out of wedlock, whom she had to send to school. Her two children were at home in KwaMashu with her mother. The son completed grade twelve and went to a technikon where he obtained a diploma in computer science; he is now working for ZINCOR next to Daggafontein. He does not stay with her in Daggafontein, but stays at KwaThema where there are better services. The daughter got married in Durban and was working until she had a car accident. This is why she (Mrs Shezi) took the two granddaughters to stay with her in Daggafontein.

10.5.2.2 The Characteristics of the Respondents.

Number and Age

The total number of the respondents in the sample is 60. Female respondents constituted 71.6% (43) of the total sample population and their age on average was 37 years. Men comprise 28.3% (17) of the sample population, with an average age of 32 years. The respondent population is thus reasonably young. This could be explained by the fact that most interviews were conducted during the week when most heads of house who are older, were at work. This also explains why the majority of the sample population is female. Most heads of house are men who work at the firms nearby.

Education

Only 16.6% (10) of the respondents have completed grade 12. Of these ten individuals, 30% (3) are male, while the percentage of female matriculants is 70% (7). The average age of these matriculants is 30 years for men and 27 years for women. There is only one person who has a tertiary education qualification. He is 28 years old.

Those who did not complete their high school constitute 46.7% (28) of the total respondent population. Of these, 28.5% (8) are men and 71.4% (20) are women.

Those respondents who dropped out at the primary level make up 26.6% (16) of the total respondent population. Of these 16 people, 18.7% (3) are men whose average age is 34 years, while the majority of 81.2% (13), are women whose average age is 41years.

Those who did not go to school at all make up 8.3% (5) of the sample population. Of these five people, 3 are females with an average age of 44 years, while 2 are males, of an average age of 30 years.

Measured against the roughly 30% / 70% male/female composition of the interview sample, there are no significant differences in the educational levels of men and women, with one-sixth of the sample having completed matric, and one-third not having made it beyond primary school.

Marital Status

38% (23) of the respondents are married. Of these married respondents, 34.7% (8) are men and their average age is 40 years, while 65.2% (15) are women, with an average age of 37 years. The male / female imbalance that seems to be the case here, is due to the fact mentioned previously: that most interviews were conducted during the week when most (married) men are away at work.

Significantly, half of the sample population (30) are single – again, roughly along the proportions of the sample. The greater age of unmarried women (33 years) as opposed to men (25 years) could reflect the poverty in the settlement, as it is a characteristic of many poorer informal settlements that women prefer to remain single, so as to have greater freedom, and say over the way that they earn an income, and how they dispose of it.

Widows make up 8.3% (5) of the sample population (60), with there also being 2 (3%) divorcees; in each case, their average age is 49 years.

Relation of Respondents to the Head of House

In the sample of 60, there are fourteen female and nine male heads of house, i.e. 23 (or 38.3%) of the respondents. Of the remaining 37 respondents: fourteen (23.3%) were the wives of the head of house; girlfriends of the heads of house made up 18.3% (11) of the respondents; brothers of the head of house were 6.6% (4), and there were 2 tenants (3.3%). Other respondents (1 in each case) were respectively: an employee, a sister, a daughter, a son, a distant relative of the head of house, and a non-relative.

Access to Pensions or Grants

There are 4 households with access to a child support grant and only one receiving an old age pension. Thus, 8.3% (5) households in Daggafontein have people with access to a government support grant or old age pension. Sixty per cent (37) have relatives receiving grants and / or pensions, who are not in Daggafontein. The remaining 30% (18) do not have any one in their household who has access to either a grant or pension. As mentioned earlier, the adult population of Daggafontein seems younger than would be the case in established rural or urban settlements, as it seems to be the case that it is mainly the economically active job-seekers that come to Daggafontein in the first place, and who stay there.

Access to Employment

In total the number of employed (i.e. currently working for a wage) respondents is 19 (31.6%). Of these 19 people, 47.3% (9) are males. Their average education is grade 9 and their average age is 36 years, while the balance of 52.6% (10) is females whose average education is grade 8 and whose average age is 40.3 years. Sample-wise, proportionately more male than female respondents are employed.

The total number of unemployed (i.e. currently neither working for a wage nor self-employed) respondents adds up to 68.3% (41). Of these 41 people, 19.5% (8) are males. Their education on average is grade 8 and their average age is 27.6 years. The female percentage of the unemployed is 80.4% (33), their average education is grade 7 and their average age is 39.

The fact that some two-thirds of respondents are unemployed, should not be taken to suggest that two-thirds of the entire adult population of Daggafontein are unemployed, as those with jobs are not around to be surveyed during week days. Pulles, Howard and de Lange (2003:7) quote an estimate that "The official unemployment rate in the Ekurhuleni area is 38%…The rate of unemployment among females (48%) is higher than among males (30.5%)".
Those who are employed are slightly better educated than their unemployed counterparts, and are also older- which makes sense, as they would have had longer to find their way into the employment market.

Length of Time in Daggafontein

Male respondents are on average 32 years old, with a grade 9 education, and they have been in Daggafontein for an average of 5.6years. Female respondents, with an average age of 37 years and education of grade 8, have spent, on average, 6 years in

Daggafontein. It is noteworthy that both men and women have spent approximately the same amount of time in Daggafontein.

Characteristics of Heads of House

Twenty-three respondents (38%) are heads of house; 9 of these are men and 14 women.

All nine men are married, with an average age of 39 years. Their average educational level is Grade 7. Six out of the 9 are employed, with the remaining three being unemployed . None of these men receive any grants or pensions. The average time that they have lived in Daggafontein is 8.3 years; with the maximum period being 22 years, and the minimum period being 2 years.

Of the 14 women, 7 (50%) are single; 1 (7.1%) is married; 5 (35.7%) are widowed and (7.1%) is divorced. Their average age is 38 years and educational level is Grade 7. Four are employed, and 10 are unemployed. None of the women receive grants or pensions. The single women have spent an average of 4.1 years living in Daggafontein, with the widows and the divorcee having spent substantially longer there. Women who came to Daggafontein with their husbands would thus appear to stay on after the termination of their marriages – presumably because of what they see as better livelihood opportunities in the urban areas.

Occupations of Members of the Household

Table 10.5a: Occupations by Frequency – Females in Daggafontein

Domestic work	12
Spaza owner	5
Catering	3
Cleaner	2
Owns a crèche	1
Social Auxiliary worker	1
Fieldwork Assistant	1
Security Officer	1
Total	**26**

Table 10.5b: Occupations by Frequency – Males in Daggafontein

Manual worker	19
Driver	3
Spaza owner	3
Mine worker	3
Security officer	3
Cleaner	3
Machine operator	2
Engineering assistant	1
Office administrator	1
Total	**38**

The spaza owners and the woman who runs a crèche work for themselves, while all the others are all working for a wage.

Entrepreneurship

Lending and Borrowing Money

Of the sample population of 60 respondents, 78.3% (46) move money around, either by lending or borrowing, as follows:

43.5% (20) borrow and lend money
43.5% (20) only borrow money
13% (6) only lend money
6.3% (3) borrow money for business endeavours.

Some 9 people (15%) of the total sample thus show entrepreneurial potential, as they either lend money, or borrow it for entrepreneurial purposes.

Thirty-five (58.3%) respondents have a family member who has their own business. Most of these businesses are small-scale and cater for people who live in their home (rural) areas. Some 42% (25) do not run businesses and do not have a family member who does.

Case Study J: Mrs Ngubo (Pseudonym)

Mrs Ngubo borrows money for her crèche. She often needs money to buy fuel so that the children are warm in the cold weather. She also borrows money for various other reasons. We here give some background information about her family. Mrs Ngubo is 48 years old and originally from Denelton in Middleburg. She has stayed in Daggafontein for about 11 years. She has three household members in Daggafontein with her. At home in Denelton she has 5 other members of her family. They usually visit her every two weeks. They come to get the money and other things which they need for the house at home. Her parents-in-law are both very old and receive pensions. She is the only working member of the family, and she is self-employed. She regards both Daggafontein and Denelton as her homes. In both these places she has ties. At home she has family ties and in Daggafontein she has crèche ties, and she has spent a lot of time in Daggafontein, so she also regards it as home. Her family *struggled financially, with her mother selling clothes to make ends meet. She went to school up to grade 7. Her parents could not support her financially. She married Mr Ngubo in Newcastle, and she came with him to Johannesburg, looking for employment. He has subsequently passed away. She has three children and a fifteen year old granddaughter. Her older son went to school up to grade 9 and could not continue because of financial problems. Her younger son is hopefully going to complete school. He is now in grade 9. The elder son is now 30 years old.* ***.*** *When they came to Johannesburg she worked for a firm called CNC; she then moved to Booysens Hotel, still in Johannesburg. After some time she left the hotel and got a job in a hospital, where she worked until 1975. She had to stop working because she fell ill. Since then she has been self-employed, selling clothes. This year she opened a crèche which currently has seven children with ages ranging from one up to four years. She wants her crèche to grow. It is not a registered crèche, but it is her own initiative. She charges by the month. She still needs more space, toys and things to cook. She wants to register her crèche if possible in future. She thinks that she can actually make a living out of running her crèche. The reason why she chose to start a crèche is that children love her and she loves them, and that their parents trust her.*

What People Use Money For

The following table attempts to rank the importance of the things people use money for, in terms of the number of people registering a particular reason for expenditure. Some respondents mentioned more than one of the reasons listed in the table.

Table 10.6: Things that People Spend Money On

Reason	*Frequency*
'Survival'	25
Remittances	21
Transport	13
Health	8
Funerals	4
Fuel	4
School fees	4
Business	3
Debts	2
Livestock	1
Total	**85**

'Survival' is thus by far the principal item of expenditure, whether directly, for people living in Daggafontein, or by way of remittances, to support people living in the rural areas. People would appear to have very little, if any, disposable income outside of the demands of survival.

Experience of Cultivation

The 23 heads of household who answered the questionnaire stated that, if given the opportunity to grow crops:

i) 18 (78.2)% of them would sell and eat the produce
ii) 3 (13%) would only eat the produce
iii) 2 (9%) would only sell the produce

There thus appears to be room for entrepreneurial development in relation to marketing of crops.

Table 10.7: Experience of Cultivation (Yes)

Age	Gender		Average Education	Average age
	Male	**Female**		
20-29	7	11	Grade 7	35 years
30-39	3	7		
40-49	2	7		
50-59	2	4		
Totals	**14**	**29**		

43 (72%) said that they have agricultural experience, with the gender split approximating that in the sample.

Table 10.8: Experience of Cultivation (No)

Age	Gender		Average Education	Average Age
	Male	**Female**		
20-29	2	6	Grade 8	36 years
30-39		3		
40-49		3		
50-59		3		
Totals	**2**	**15**		

17 (28%) said that they have no experience of cultivation, with disproportionately more women (88% of the group) lacking in experience

Would People take Money to Start a Business, or Rather have a Job?

In order to try and identify possible entrepreneurial potential, respondents were asked questions to see if they would prefer to take a job if offered it, or rather to take money to start a business. The understanding was that this would be in an urban area, and so could include Daggafontein. They replied as follows:

Table 10.9: Would Take Money to Start their Own Business

	Count (60)	**Percentage**	**Ave. Educ**	**Ave Age**
Female	24 / 43	56	Grade 8	39 years
Male	7 /17	41		
Total	**31/60**	**52**		

Case Study K: Mr Mashazi (Pseudonym)

Mr Mashazi is on the street committee and would love to get money so that he could start a hairdressing business in Daggafontein. The case study briefly gives his background. Mr Mashazi is 38 years old, originally from Mount Frere in the Eastern Cape. He has stayed in Daggafontein for 11 years. He is married and has 4 children. One of the children is at home in Mount Frere, and the other 3 are with himself and his wife, as they are still too young to attend school. After completing his matric he went to university to study law. He dropped out in his second year because of financial problems. He started looking for a job. He worked at Mossel Bay for 18 months, moved to George and then came to Springs. At first he stayed at Strubenvale. He then came to Daggafontein, because he has home connections there and it is affordable as there is no rent. Where he used to stay he had a very small room, which can't accommodate his family. In Daggafontein he has a big nicely built shack. He also came because there were rumours that houses would be provided. He is currently working as a security officer in town (Springs). He says if he could get money he would start a business. He is aware of the too many businesses around and thinks the market is now saturated especially in terms of Spaza shops. He would take a different route. He would like to open a salon. The only hindrance to this is that there is no electricity, nevertheless thinks that he can start as soon as he gets money (he is fully aware that there is no electricity). There are no salons around so people have to go all the way to town. Mr Mashazi would like to see changes in terms of proper housing being provided to the people of Daggafontein.

Table 10.10a: Would Take a Job, rather than Money to Start a Business

Females			
Age	**Count**	**Average age**	**Average education**
20-29	9	34 years	Grade 9
30-39	5		
40-49	2		
50-59	3		

Total of 19 out of 43 female respondents (44%)

Table 10.10b: Would Take a Job rather than Money to Start a Business

Males			
Age	**Count**	**Average age**	**Average education**
20-29	8	28 years	Grade 9
30-39	1		
40-49	1		
50-59	0		

Total of 10 out of 17 male respondents (59%)

So, the sample was split pretty much down the middle, in terms of being prepared to take a risk on a business venture, or preferring to play safe and take a job, with those being prepared to take a risk on a business being slightly older, and with women being more prepared to take the risk, and with men more inclined to go for the security of a job.

Case Study L: Mr Mbizi (Pseudonym)

Mr Mbizi is currently looking for employment. He has a certificate in Basic Business Appreciation and another certificate in Participative Leadership. However, at present he is desperate and will take any kind of job so as not to go back home. Mr Mbizi is 27 years old and from Mzimkhulu (KwaZulu-Natal). He is married and has two children, whom he visits once a year. He has stayed in Daggafontein for 4 years. He is using his sister's shack and shares it with three of his brothers. At home are his wife, his two children, and his mother. Two of his other family members (a brother and a sister) are in Durban. He has stayed and worked in Orlando East, Kathlehong and then Daggafontein, where he has been getting piece jobs. He went to Orlando East College in Gauteng. At home the family depends on his mother's pension. They also have other resources at home such as livestock and fields. According to Mr Mbizi all these things can't help him, as what he needs is a job. He regards Mzimkhulu as home; he is in Gauteng only because he is looking for a job. The only place where he worked fulltime was in Durban, where he was retrenched. He says he cannot work at home because there are no jobs in the rural areas. Besides, all his connections are in Gauteng.

Table 10.11: Would take a Job at Home (i.e. not in Daggafontein)

Females				**Males**			
Age	**Count**	**Ave age**	**Ave Educ.**	**Age**	**Count**	**Ave age**	**Ave Educ.**
20-29	13	36	Grade8	20-29	8	31	Grade 8
30-39	5			30-39	1		
40-49	8			40-49	2		
50-59	6			50-59	1		
Total	**32/43**			Total	**12/17**		

Seventy-three per cent (44 out of 60) would take a job at home in the rural areas, with females being several years older than men and therefore possibly feeling more marginal to the urban economy, with its bias towards male jobs in the formal sector. There clearly is an overlap between respondents who would start a business or take a job in town, and those who would take a job at home – and this table tells us that people still identify strongly with their rural areas of origin.

Table 10.12: Would Not Take a Job at Home

	Count	**Percentage**	**Ave. Educ**	**Ave Age**
Female	10 /43	23	Grade 8	37 years
Male	5 /17	29		
Total	**15/60**	**25**		

These respondents (25 per cent of the sample) did not know whether they would take a job at home. One of them is currently unemployed and one is running a spaza shop. These are people who identify with Daggafontein either for positive reasons, or because of relationship or other difficulties in going home.

Resources at Home

One-third (20) of respondents have someone who has resources in the rural areas, as follows.

i) 50% (10) have land, livestock and a house
ii) 25% (5) have a house only
iii) 10% (2) have livestock only
iv) 5% (1) have land only
v) 5% (1) have land and livestock
vi) 5% (1) have land and a house

Just over half of the respondents have a member of their family who runs a business at home in the rural areas. This suggests a wider pool of entrepreneurial talent, which could be attracted if a development initiative such as growing vegetables under hydroponics were to get under way in the Daggafontein area.

Table 10.13: Has someone in their Family who runs a Business at Home (i.e. not in Daggafontein)

Females				**Males**			
Age	**Count**	**Av age**	**Av educ**	**Age**	**Count**	**Av age**	**Av educ**
20-29	11	35	Grade 8	20-29	3	36	Grade 6
30-39	4			30-39	1		
40-49	7			40-49	1		
50-59	3			50-59	2		
Total	**25**			**7**			

Several of these businesses are not single-trade undertakings. Of those that were identifiable:
eleven of these small businesses are spaza shops, which sell general groceries. Most of them make a profit, and use the money to buy stock, and food for their families. Their main problems are not having enough capital, theft, and customer debts.

Seven of the businesses are phone shops with tuck-shops which sell general goods on a very small scale. Their problems are mainly theft and customer debts. Most of the money they earn is put back into the business.

Four are transport services, which operate taxis. Due to the fact that there are numerous taxi-operators, most of them face the problem of stiff competition. Thus they do not make much, if any, profit. They also face high vehicle maintenance costs because of careless drivers.

Three are tailors who make and sell clothing. They mainly face the problem of customers not paying their debts, and they thus have insufficient money to buy more materials. Three grow and sell vegetables. Because of the high demand, they are always sure to sell their products, but at times their profits are low due to the fact that livestock have destroyed some of their crops. Their produce and the money made from it are used to support the family at home.

Where is 'Home'?

In an attempt to understand something of how people saw the balance of their Commitments and identifications between Daggafontein and the rural areas – and thus whether they would be likely to identify with a development project in Daggafontein area, respondents were asked about where they saw "home" as being. They replied as follows

Table 10.14: Regard Daggafontein as home (16 /60)

	Gender	
Age	**Male**	**Female**
20-29	1	0
30-39	2	4
40-49	0	6
50-59	0	3
Their average educ. is Grade 7		
Totals	**3 (18%)**	**13 (23%)**

Table 10.15: Regard Both their Place of Origin and Daggafontein as Home (7/60)

	Gender	
Age	Male	Female
20-29	0	2
30-39	1	0
40-49	0	1
50-59	1	2
Their average educ. is Grade 9		
Totals	**2 (12%)**	**5 (12%)**

Table 10.16: Regard Their Place of Origin as Home (37/60)

Age	Gender	
	Male	Female
20-29	**8**	**14**
30-39	**0**	**6**
40-49	**2**	**4**
50-59	**1**	**2**
Their average educ. is Grade 8		
Totals	11 (65%)	26 (60%)

Table 10.17: Summary: Where is Home?

'Home'	37	61.6%
Daggafontein	16	26.6%
Daggafontein and 'home'	7	11.5%
Total	**60**	**100%**

People still retain a very strong identification with their (predominantly) rural areas of origin, with only just more than a quarter unambiguously regarding Daggafontein as "home". Men tended to identify more strongly with their rural areas of origin than women did – presumably because of the rural land tenure, religious and status systems being more male oriented. Their land and their ancestors are in the rural areas.

In order to get an idea of what such an identification with "home" meant, respondents were asked where they held 'traditional' ceremonies (i.e. ceremonies that involve the slaughtering of an animal for the ancestors): at their rural home, in Daggafontein, or both? They replied as follows:

Where are 'Traditional' Ceremonies Held?

Table 10.18: Traditional Ceremonies Held Both At Home And Daggafontein

Age	**Male**	**Female**	**Av educ**	**Av age**
20-29		1	Grade 6	45 years
30-39				
40-49	1	5		
50-59		2		
Totals	**1**	**8**		

Nine people (15%) hold their traditional ceremonies both at home and in Daggafontein. They are women in all cases but one.

Table 10.19: Traditional Ceremonies Held at Daggafontein

Age	Male	Female	Ave educ	Ave age
20-29			Grade 4	44 years
30-39		2		
40-49				
50-59		2		
Totals	**0**	**4**		

All of these people who hold their traditional ceremonies in Daggafontein are women. They constitute 7% of the sample population and are all currently not working. As women, it is not clear who conducts their ceremonies for them, including the actual slaughtering of the appropriate animal.

Table 10.20: Traditional Ceremonies Held at Rural Home

Age	Male	Female	Ave educ	Ave age
20-29	8	13	Grade 8	32 years
30-39	2	4		
40-49	1	2		
50-59	2	3		
Totals	**13**	**22**		

As might be expected, men are more strongly represented in this grouping than women (76% of male respondents as opposed to 51% of female respondents).

Table 10.21: Do Not Hold Traditional Ceremonies

Age	Male	Female	Ave educ	Ave age
20-29	2	2	Grade 9	35 years
30-39	1	4		
40-49		3		
50-59				
Totals	**3**	**9**		

12 (20%) in Daggafontein do not hold traditional ceremonies. Reasons for them not holding any traditional ceremonies are: i) some are 'coloured' and do not practice any traditional ceremonies. ii) they are a young couple who have just started their own home, and no longer partake in traditional ceremonies. iii) they have left their families and have nothing to do with traditional ceremonies. These are people with some degree of independence, with two of them running spaza shops and are financially independent. Education does not seem to play an urbanising, secularising role, as those who hold ceremonies at home are as educated as those who hold no ceremonies at all.

Where are the Children? In Rural Areas or in Daggafontein?

There are 142 children associated with the 60 sampled households; 82 of these children live in Daggafontein, (57.7%), 52 live in rural areas (36.6%) and 8 (5.6%)

live elsewhere in urban areas. Of the 82 children who are at school, 42 (51.2%) children go to school in Daggafontein, 35 (42.7 %) of the children go to school in rural areas, and 5 (6.1%) children go to school in urban areas. The children in the rural areas are presumably living with parents who cannot find employment in the urban areas, or who have some agricultural resources or a small business in the rural areas

What Job Would You Take?

People were asked, if they could choose any job, what it would be. This was asked to try to get another perspective on their relative urban or rural identification, in terms of whether certain jobs potentially had a more urban set of associations attached to them.

Table 10.22: Preferred Male Occupations

Occupation	**Total out of 17**	**Percentage**
Mechanical Engineering	5	29.4
Farming	2	11.7
Business Administration	2	11.7
Any Job	2	11.7
Chemical Engineering	1	5.8
Office Administration	1	5.8
Social Worker	1	5.8
Electrical Engineering	1	5.8
Traffic Officer	1	5.8
Machine Operator	1	5.8
Total	**17**	**100**

Table 10.23: Preferred Female Occupations

Occupation	**Total Number out of 43**	**Percentage**
Business Administration	11	25.5
Catering and Hospitality	10	23.2
Any Job	10	23.2
Farming	3	6.9
Dress making	3	6.9
Computer Science	2	4.6
Hairdressing	2	4.6
Teaching	1	2.3
Radio DJ	1	2.3
Total	**43**	**100**

Both men and women overwhelmingly opted for urban type jobs – presumably because these jobs usually pay more, but possibly also because of the urban lifestyle with which they are associated.

Rural-Urban Visits and Linkages

The majority of people take money and food home, i.e. mainly to the rural areas. Their visits are mainly during the holidays at the end of the year. However, some people (such as those who are from the neighbouring townships) go home as frequently as every week. There are those also who visit home once a year when they get leave from work. When asked if they involve people from their home areas in making important decisions in Daggafontein, the answer was overwhelmingly in the affirmative, with only 7 (11.6%) saying that they did not do so. In their actual behaviour patterns, most people thus demonstrate strong links to, and identification with, their areas and families of origin.

The main themes from the research findings, and their implications, will be discussed in the following Assessment and in the Conclusion.

10.6 ASSESSMENT OF WHETHER A HYDROPONICS INITIATIVE IS POTENTIALLY VIABLE IN COMMUNITIES SUCH AS DAGGAFONTEIN

If successfully implemented, a hydroponics based project could be a major catalyst for local community development, in terms of stimulating vegetable production, creating jobs and substantially boosting income and nutrition levels within poor urban communities, which are typically characterised by very limited service provision, moderate formal education, low levels of market related skills, and consequently, high unemployment, relatively few options and limited autonomy.

However, hydroponic cultivation is a demanding undertaking. It is "management, capital and labour intensive" (www.arc.agric.za/insititutes/roodeplat/main/topprojects) It requires high levels of initial capital, as well as agricultural and management expertise, including financial and marketing expertise, and a committed and trained labour force that is prepared to put in work on a daily basis, i.e. 7 days a week, all year round. Equipment needs to be kept in perfect working order around the clock, and nutrients, insecticides and sufficiently clean water need to be available all the time. It is a high input venture, with little margin for error.

Such capital and skill intensive undertakings tend to be run in a top-down fashion. While this may be good for producing high yields and incomes, which potentially put more food and money into the hands of the poor, that is only one side of the development equation. While development is certainly about increasing access to resources, it is also about increasing what is loosely referred to as the 'ownership' of such undertakings, and thus 'empowering' the local people in a sustainable fashion, such that they can carry on the venture by themselves.

A hydroponics venture aimed at boosting vegetable production, jobs and incomes in poor communities which are short on skills, such as Daggafontein, may well need to strike a compromise between the development goals of increasing access to resources, and local 'empowerment' – at least in the short term. But if it is to be a genuine development project, the participating communities around Grootvlei Mine are increasingly going to have to manage, and even fund, it by themselves.

Thus, while a grant funding agency would presumably fund the initial installation of all the necessary equipment and infastructure, all future costs such as new equipment or repair of existing equipment, fencing, etc. as well as ongoing purchase of seedlings, fertilisers, insecticides, and the costs associated with marketing, would increasingly have to be borne by the project. Which is why production and profit margins would have to remain healthy. While the expertise required to maintain those positive margins, as well as the necessary training at all levels of the enterprise might initially be arranged and funded by the funder (perhaps in association with foreign funders), once again the project would have to take over and fund these functions. Water is increasingly being seen as a vendable commodity, and it is not unlikely that in future

a hydroponics project associated with Daggafontein and similar settlements will have the pay for the clean water it needs to sustain itself. All of this calls for effective, entrepreneurial, fiscally sound and strong management, at all levels of the project.
While the funder might initially supply a manager to help the project and its participants settle in and find their feet, to be sustainable the project is going to have to provide or recruit its own managers and training, and handle its own relations with wider organisational institutions, such as local government, suppliers, markets and Inland Revenue. The project management is also going to have to keep its labour force committed, trained, disciplined and productive.

The fact that a large amount of water is suddenly potentially available provides a powerful incentive to utilise it for development purposes, and may in itself create pressure for such a project to be implemented. However, to succeed, it is going to have to be negotiated and worked through with the community, in such a way that people clearly understand what is involved, the potential as well as the risks, and the need for reliability on the part of the labour force. Different interests groups will doubtless seek to annex such a new source of potential wealth, and the support of local government as well as the local ANC branch will have to be obtained. Unless all the relevant constituencies buy in, and unless the local communities identify with it – and securing such identification could well be a time-consuming process – the project is likely to become another expensive failure.

10.6.1 Does all of this seem feasible, given the socio-economic profile of settlements such as Daggafontein?

Education levels in Daggafontein are moderate, with only one-sixth of respondents having completed the full 12 years of schooling, and with only one of these having any tertiary education. Very few appear to have skills wider than those acquired at school, or in a work specific context, such as being a driver or a machine operator. While our sample thus does not seem to show potential for senior management positions, these matriculants certainly would have the qualifications necessary for more administrative jobs, such as record keeping and monitoring, ordering of seedlings, fertilizer and insecticide, correspondence, etc. Those who establish themselves as competent in these tasks, could then move into lower level management tasks, such as supervising groups of manual labourers in the shade tents. The majority of jobs performed by people in Daggafontein are of the more repetitive kind, such as domestic servants or manual labourers. Given that almost half of respondents have some high school education, they would thus seem suited to a manual job that would nevertheless require functional literacy and numerical competence, in administering nutrients, etc. on a regular basis, and keeping basic records.

Nearly three-quarters of respondents have some experience with cultivation, whether in their home areas (mainly in the former homelands) or on commercial farms. This experience has, however, not translated itself into the desire to cultivate in Daggafontein, given the handful of people who are actually active in the community garden, and the fact that all its plots have not been taken up. Only two or three people

actually sell any of their produce. Daggafontein would seem to be fairly typical in this respect – as argued earlier in this report, small scale urban agriculture is practised to only a limited extent, presumably because of the 'cycle of lows', resulting in returns which are not seen as sufficient to justify the activity in the first place. Small scale urban cultivation is thus, for the most part, a marginal activity at best.

If the scale of the operation, and of returns and incomes, were to be dramatically increased, as in a hydroponics project, where people would have the direction and the discipline of being employed, as well as the assistance of advisors and the supervision of managers, the motivation to participate would certainly increase among a percentage of the members of such communities. While their previous experience of cultivation is of dryland cultivation in limited rainfall areas, it would nevertheless stand them in good stead, as a general background competence for hydroponic cultivation.

There is a fair amount of entrepreneurial potential in Daggafontein, with some 15 per cent of the sample working for themselves, either running small spaza shops, or in one case, a crèche, and the same percentage either lending money or borrowing it for business purposes. Some of these people are looking to expand their enterprises. These are risk takers, who would be more likely to take a chance on switching economic activities and taking a chance on getting involved in the hydroponics project. They could then act as the example and the demonstration effect for other, initially more cautious, people to join up. More than half the sample have relatives in their home areas who run their own small businesses. So, while branching out on one's own may not be widely practised among the respondents themselves (possibly because of a lack of access to start up capital), enterprise is part of their family experience. Respondents were asked the hypothetical question: "If I offered you money to start a business, or a job, which would you choose?" While it is certainly easier to talk than to do, just more than half the sample chose for the money to start a business of their own. One way and another, there are positive indications of an entrepreneurial spirit in Daggafontein, which is not surprising, as the mainly youngish adult population of Daggafontein has already displayed entrepreneurial behaviour by coming there to look for a job and as a jumping-off plank to better themselves. These more entrepreneurially minded people could supply the ranks from which future managers are drawn.

Are its residents committed to Daggafontein? In terms of a number of criteria, such as where they regard as 'home", where they hold traditional ceremonies, where their children are, where they would take a job if offered one, how long they have been staying in Daggafontein, and patterns of visiting, it is clear that many people in Daggafontein identify strongly, and seemingly in a primary sense, with their home areas. Daggafontein is seen in the first instance as a place where people come to work. On the other hand, a number of people have started investing in consumer goods designed to make their stay in Daggafontein more comfortable. If anything like permanent employment with worthwhile remuneration were to be become available, and services in Daggafontein were to be significantly improved, people's perceptions of 'home' might well become more flexible. In fact, in contrast to the claim by over seventy per cent of respondents that they would like to take a job at home, a potentially urban orientation emerges when people identify the kind of job they would like to do – the majority of the jobs listed in Tables 11.22 and 11.23 above clearly relate to the urban context. They also indicate an urban identification in as much as many of the listed jobs require a level of education that the respondents clearly do not have; they thus seem to be identifying with what they perceive as urban-based status and income patterns and activities. If the potential incomes promised by a successful hydroponics initiative could be linked up to the resolution of two of the residents' other sources of grievance, i.e. the lack of services and of formal housing, people's reasons for identifying with Daggafontein – and therefore with the project – would be considerably enhanced.

The project will need to liaise and work closely with local government if it is to be accepted and to succeed. In the case of Daggafontein and other settlements around Grootvlei Mine, this would involve dealing with Ekurhuleni, and more specifically, with Ward 50. Our research suggests that Ward 50 might not function all that effectively. The Ward Committee is supposed to meet once a month, but does not manage to do so, as a number of its members are at work at times when meetings are scheduled. Local government institutions do generally not function at optimal level in many South African contexts, as they are also struggling with shortages of experience, skills and resources. The project could be seen as a possible milch cow and/or banner project by Ward 50 or the Ekurhuleni Metro, which would confront the project with both opportunities and challenges it would have to deal with. The relationship with local government is going to have to be developed pro-actively and systematically, and sound working relationships cultivated on an ongoing basis.

10.7 CONCLUSION

While it has substantial potential to capitalise on the water to be made available via the BioSURE® technology and produce food, jobs and significant incomes in poor areas such as the informal settlements and townships near Grootvlei Mine, a capital intensive, high input initiative such as a hydroponics project will ultimately stand or fall by the quality of its management, and in particular, its top level management. It is unlikely that the informal settlements and the neighbouring townships in the vicinity of Grootvlei Mine will be able to provide the necessary calibre of top management. People with the necessary qualifications and ability are likely to be holding down well paid jobs, and have probably moved out to more up market residential areas. Settlements like Daggafontein and the nearby townships such as Kwa Tema will be able to provide sufficient numbers of entrepreneurially minded people who are prepared to take a chance on the increased income levels offered by a hydroponics project – whether as labourers, or, if more suitably qualified and capable, as administrators or lower level management. But it would seem that the top level managers, agricultural experts and financial managers are going to have to be sought on the open market – and paid accordingly. The project will need to be sufficiently profitable, to be able to hire such managers to run it effectively.

In order to succeed, the envisaged hydroponics project will need to:

- bring the local communities and local government on board
- find the necessary starting up capital
- attract and keep efficient top level management
- maintain and motivate a trained, disciplined and productive workforce
- secure and maintain its supply networks and market outlets
- develop and maintain sound working relationships with local government and other important stakeholders.

Indicators for potential success include

- Available expertise to treat the polluted mine and sewerage water
- Sufficient treated water for hydroponic cultivation
- Available land in the area for developing hydroponic cultivation
- Potentially large amounts of semi-skilled labour in informal settlements and townships near Grootvlei Mine
- Training Resource, Experimental Facilities via ANCOR Sewage Works
- (Predominantly small scale) Entrepreneurs in communities such as Daggafontein
- Potential markets for hydroponically produced vegetables in the surrounding townships and in the Ekurhuleni Metropolitan Municipality
- Supportive Response from officials at Ekurhuleni Metropolitan Municipality

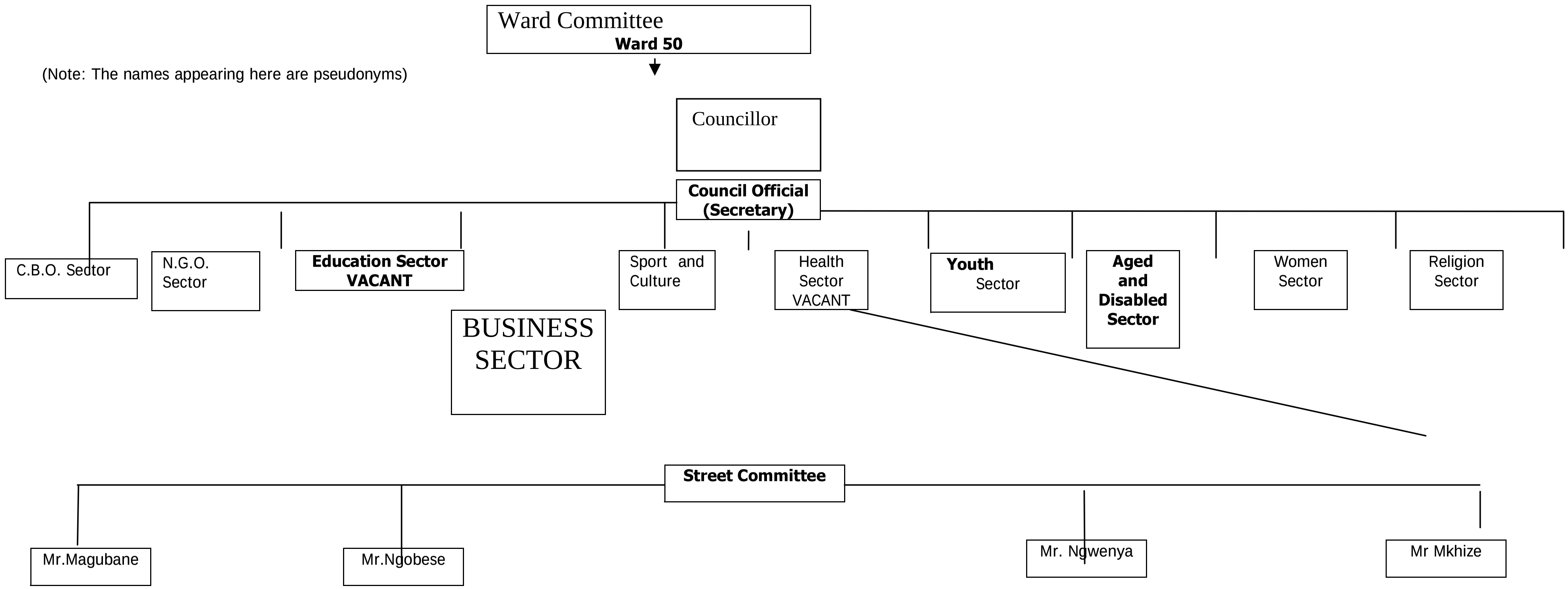
Indicators for potential failure or problems include

- The capital-, management- and labour intensive nature of hydroponic cultivation
- Senior level administrative and financial management will have to be recruited from outside, therefore there will be a continuous 'top down' component to the project, with community members always being in only the more junior administrative positions
- Need for "24/7" availability of labour
- Strong rural component in the responses and behaviour patterns of many of the respondents interviewed
- Limited effectiveness of current local leadership and local government structures
- Inevitable political tussles when significant new resources are made available- which could be severely disruptive in the context of local government structures that are still struggling to find their feet and operate effectively.

APPENDIX A

Elected 19, 25 March 2002 and 4 April 2002

(Note: The names appearing here are pseudonyms)



APPENDIX B

DAGGAFONTEIN SOCIO-ECONOMIC SURVEY: 2003

Name of Interviewer:……………………………..………………
Date of Interview:………………………………………..…….

SECTION 1

1. Area of Origin ………………………………………………………………

2. How long has your family lived in Daggafontein? …………………………….

3. Details of Respondent

NAME	**M/F**	**Age**	**Educ.**	**Occupation**	**M/S/D**

4. Relation to Head of House ………………………………………………………..

5. Who is head of house?

Name	**M/F**	**Age**	**Education**	**M/S/D**

6. Household Members here in Daggafontein

Name	**M/F**	**Age**	**Educ.**	**Occup.**	**M/S/D**	**Rel. to Head**
a)						
b)						
c)						
d)						
e)						
f)						

7. Household Members away

Name	**M/F**	**Age**	**Educ.**	**Occup.**	**M/S/D**	**Rel.to Head**	**Where are they?**
a)							
b)							
c)							
d)							
e)							
f)							

8. How often do they visit Daggafontein ?

a)……………………….…**b)**……..………………….…**c)**…………

d)……………………………**e)**…………………..………**f)**……………

9. How often do they visit your home area ?

a)……………………….…**b)**……..………………….…**c)**…………

d)……………………………**e)**…………………..………**f)**……………

10. Do they remit ? | Yes | No |

(if yes above)

i).**Goods**

a)……………………….…**b)**……..………………….…**c)**…………

d)……………………………**e)**…………………..………**f)**……………

ii). **Money**

a)……………………….…**b)**……..………………….…**c)**…………

d)……………………………**e)**…………………..………**f)**……………

SECTION 2.
AGRICULTURAL SKILLS

1. Do any members of your household (home or away) cultivate? | Yes | No |

2.Who?……………………..……………………………………………….

3. Where? ………………………………………………………………..

4. What do they cultivate? ….…………………………………………………

5. Why? …………………………………………………….………………

……………………..…………………………………………………………

6. Do they sell any of their crops? ………………………………………….

7. Where? ……………………………………………….…………...…………

8. What problems do they find with cultivation? …………………………………...

………………………………………………………………..………………

9. What do they do with the money from the crops? …………………………...…..

………………………………………………………………………………………

10. Do they make profit from selling crops? ……………………………………...

11. What is the most important problem they need help with in cultivating?

………………………………………………………………………………...…

…………………………..………………………………………………………

12. What foods do your household eat? ……………………………………………

………………………………………………………………………………

………………………………………………………………………………

13. Where do you obtain your food? ………………………………………………

………………………………………………………………………………

14. How often does your household eat:

Type of food	**Daily**	**Weekly**	**Monthly**
Mealie Meal			
Samp			
Green Vegetables			
Potatoes			
Rice			
Tea/ Coffee/ Sugar			
Chicken			
Beef and Mutton			
Pig Meat			
Eggs			
Fish			
Cheese			
Bread			
Butter/ Margarine			
Jam			
Fruit			
Other (specify)			

15. What did your household eat last night? ………………………………………

………………………………………………………………………………………

16. If you could afford it, what kinds of food would your family eat?

………………………………………………………………………………………

………………………………………………………………………………………

17. If you had land to grow crops and water to irrigate it, what crops would you grow?

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

18. Would you grow these crops to eat or to sell?

………………………………………………………………………………………

SECTION 3.
ENTREPRENEURSHIP

1.Do any members of your family run a business? (i.e. self-employed)

Yes	No

2.Who? …………………………………….……………….

3. Where? …………………………………………………..

4. What is the business? ……………………………………………………..……...

5. What problems do they find in running a business? ……………………………...…

………………………………………………………………………………………

6. Do they make a profit from their business? ……………………………..……….

7. What do they do with the money from the business? ……………………..………..

………………………………………………………………………………………

8. What is the most important problem they need help with in the business?

……………………………………………………………………………………...…

……………………………………………………………………………………………

9. Do you lend money? ………….

What for? …………………………………………………………………………..

………………………………………………………………………………………………

10. Do you borrow money?………..

What for? …………………………………………………………………………..

………………………………………………………………………………………………

11. Do you employ anybody? ………….

12. How many people? (if yes above) …………………………………………………

13. What for? …………………………………………………………………………..

……………………………………………………………………………………………

14. If I offered you a job or money to start a business, which would you choose?

……………………………………………………………………………………………..

15. If you could get a job and the training what kind of job would you like?

……………………………………………………………………………………...…

……………………………………………………………………………………………….

16. If you could get a job in your home area would you take it?

…………………………………………………………………………………………….

SECTION 4
INCOME

1. How many people in this household receive a pension or a grant? ……………..…..

Name	M/F	Old Age	Disability	Child Support	Other	Amount

2. How many people in this household are employed? …………………..………..

Name	M/F	Age	Educ.	Type of job	Place of Employment	Skills needed for the job	Earnings per month

3. Are there any people over the age of 18 who do not work? ……………..

(if yes above)

Name	M/F	Educ.	How long unemployed?	Previous Job	Skills he/she has

Do any members of your household have any resources in rural areas? ……………
(if yes)

Land	Livestock	House	Other – Specify

5**. Basic Household Expenditure**

Last week how much has your household spent on.

a) food …………… b) fuel (e.g. paraffin)………… c) rent ……….
d) transport …… e)Alcohol and/or Tobacco ………. f) church ………
g) clothing ………. h) school costs…… .. i) health ………..
j) other…………

6. What do school fees, school uniforms costs each year? …………………………….

7. What other major expenses do you have? ……………………………………….....

………………………………………………………………………………

8. How many taxis come and go from Daggafontein each day? ………………………

9. At what times of the day are the taxis busiest? ……………………………………...

SECTION 5

Urban rural interaction

1. Where do you regard as your home (Daggafontein or your area of origin)? ………………………

2. How often do members of this household go back to your home area?

Who?	**For what purpose?**	**How often?**

3. Do they (you) take anything to your home area like food or money?

Name	**Food**	**Money**	**Other**

4. How often do people from your home area come and visit here?

Who?	**For what purpose?**	**How often?**	**Relation to head**
a)			
b)			
c)			
d)			
e)			
f)			

5. Do they bring anything with them like goods or money?
…………………………………………………………………………………………

6. Where are the children of this household?

Name	**Place**	**The school they go to**
a)		
b)		
c)		
d)		
e)		
f)		

7. Where do you hold traditional ceremonies: here or at your home area?…………………………...…………………………………………………
………………………………………………………………………………
……………………………..

8. When you make important decisions here (e.g. about money, illness ceremonies) do you involve people from your home area?
………………………………………………………………………………
………………………………………………………………………………
……………………………..

11 CONCLUSIONS

FEASIBILITY OF AN IRRIGATED AGRICULTURE-BASED SPATIAL DEVELOPMENT IN EASTERN EKURHULENI

11.1 INTRODUCTION

The objective of this study was to evaluate the downstream agricultural beneficiation of wastewaters from the Grootvlei Mine treated in the Rhodes BioSURE Process®. Although the use of mine wastewater treatment as a resource development operation has not received wide attention in South Africa, the potential for its use in the social development and economic empowerment context is substantial, and has been examined here. This is of particular importance, especially in areas where economically depressed conditions follow mine closures, and where large unemployment problems occur, including the growth of indigent informal settlement communities. It is evident that particular synergies of interest exist between the community and the needs of the mining organisation to achieve final closure, and the treated wastewater provides a resource on which sustainability may be built in the economic, environmental and social contexts.

This question was tackled by a multidisciplinary team lead by Rhodes University EBRU, and the Grootvlei Mine/Blesbokspruit area was chosen as the study site. The specific proposal to be considered was a feasibility assessment of an irrigated agriculture-based Spatial Development Initiative located in the Springs/Nigel mine lands corridor, using treated water from the Grootvlei Mine, and preferably involving people currently living within this area.

Studies by Scott (1995) have shown that mines in the East Rand basin area will decant within a few years once Grootvlei Mine finally closes, and a long term solution will have to be found for some 30-50ML/day of polluted minewater, which is likely to flow for many decades and possibly centuries. The solution examined here is the linkage of mine and sewage wastewater treatment operations to provide the required long-term treatment using the Rhodes BioSURE Process®, among other possible technologies, and the profitable use of the treated minewater in social development to ensure the equivalent long-term sustainability of the operation.

During the period this project was in progress, Grootvlei Mine undertook a technology evaluation study to identify the minewater treatment process to be implemented. In late 2004 the Rhodes BioSURE Process® was identified as the technology of choice with linkage to ERWAT's Ancor Works nearby, and the solution was launched in January 2005. Treatment of 10ML/day is scheduled by September 2005.

The questions to be answered in this study included:

- The suitability of the site and an assessment of the physical planning implications in the establishment of an SDI in this area;

- The suitability of water, soils and climate for irrigated crop production in the region;
- The economics of large-scale agri-business farming to both absorb the treated water and provide jobs;
- The economics of intensive high-value small-scale farming focussed principally on entrepreneur development and self-employment job creation outcomes;
- A social assessment of the local communities involved and the indicators for success or failure in their involvement in the proposed project.

11.2 PHYSICAL ASSESSMENT

Physical planning and site assessment was undertaken by Pulles, Howard and de Lange Inc. and involved mapping of the site, establishing current land use patterns and existing spatial development planning by EMM. The population distribution and socio-economic characteristics of the area was considered and water resource usage reported.

This study indicated that an area of about 2600 ha was available in the Springs/Nigel corridor. While this would need ground-truthing in a detailed follow-up study, both suitable agricultural soils and spoiled mine ground and reclaimed dump areas were identified. The latter could be used for hydroponics production where direct soil contact should be avoided.

In assessing the quality of the BioSURE® treated minewater, it was noted that sodium chloride salts would not be removed. A dilution option was examined in which the treated minewater would be diluted with Ancor WCW effluent to reduce the impacts of the sodium component on the receiving water and irrigated soil quality. This was subsequently accepted by the Department of Water Affairs and Forestry (DWAF) and now forms a component of the Grootvlei minewater treatment programme.

The study drew attention to the needs of existing irrigation farmers downstream of the proposed SDI site and that equitable water use will need to be considered in the proposed development. DACEL buffer zone policy with respect to agricultural ground would also need to be taken into account in planning the enterprise.

11.3 WATER QUALITY AND CLIMATE

An assessment of water, soil and climatic requirements for crop production in the area was undertaken by the Agricultural Research Council Institute for Soil, Climate and Water. A list of potential crops was identified which would be suitable for production in the Eastern Ekurhuleni region, and this was used in the subsequent investigations of both extensive and intensive agricultural production models evaluated.

The suitability of treated water quality for irrigation was considered for both RO and the BioSURE® treatment options. It was reported that the sodium absorption ratio (SAR) of the Grootvlei/Ancor BioSURE® treated water would only be raised about 17% in the blending operation and that this would be suitable for crop production. This compared to an elevated SAR of some 142% for the RO option, and 244% for the partly treated water, which would raise severe problems for crop production in this area.

11.4 FINANCIAL FEASIBILITY

Two models for the irrigated agricultural production enterprise were considered.

The assessment of crop production in an extensive open land operation was undertaken by Optimal Agricultural Business Systems. The economics of a wide range of potential crops was considered and a detailed costing study undertaken on the basis of a large, professionally managed agri-business enterprise absorbing all the treated water. For the 10ML/day water production scenario it was found that a net farming income of R9.3 million could be generated on a land area of 515 ha, and that 567 permanent jobs could be created in this way.

Intensive horticultural production using hydroponics systems was also investigated and reported by Public Domain Management. Intensive vegetable production was considered and local marketing conditions were examined in formulating a production programme on which a detailed costing study was based.

While more detailed studies will be required to secure a firmer concept of the proposed SDI, the studies reported here do enable the formulation of a hypothetical picture of potential water, land, and job creation potential for the scheme, and a potential net farming income may be computed based thereon. This has been summarised in Table 10.1 and indicates that some 113 farming and gardening enterprises may be established in this way and generating around 950 additional permanent jobs and a net farming income for the scheme of R26 million.

Clearly the system could act as an incubator for the development of agricultural entrepreneurial skills which could, in time, relocate to other possibly more productive enterprises.

Table 11.1: Summary of water, land use and job creation potential in a hypothetical allocation of resources in the proposed Springs/Nigel SDI in Eastern Ekurhuleni including agri-business, farming entrepreneur development and urban gardening, and utilizing 30ML/day treated mine wastewater.

	Area (ha)	Water Usage (ML/day)	Owner/operators	Jobs	Net Farm Income (R)
Agri-business	300	8	3	400	14
Farming EDP	300	8	35	300	7
Urban garden	250	14	75	250	5
Totals	850	30	113	950	26

11.5 SOCIAL DYNAMICS

Daggafontein informal settlement community has been located within the proposed SDI area for many years, and would be a major participant in the proposed scheme in terms of labour provision and possibly entrepreneur development. In order to understand the social dynamics underpinning such communities, and the indicators for their successful involvement in the scheme, a study was undertaken by the Rhodes University Anthropology Department.

It was accepted that the SDI scheme could be a major catalyst for local development, creating jobs and boosting income and nutrition levels in poor urban communities. These are typically characterised by very limited service provision, moderate formal education, low levels of market related skills, and consequently high unemployment, and with relatively few options and limited autonomy.

The proposed enterprises are both capital and skills intensive and require professional management for successful operation, and thus the settlement community may participate initially mainly in the form of labour contribution. However, more money and food into the hands of the poor is only one side of the development equation, which is also about increasing access to resources, an ‘ownership’ of such undertakings, and thus ‘empowering’ local people in a sustainable fashion so that they can operate such ventures on their own.

Based on the socio-economic profile that emerged from the Daggafontein study, the following conclusions were drawn relating to the viability of the proposal:

- Nearly 75% of respondents in the study had some experience with cultivation and came from a rural agricultural background. This provides a good indicator of success for employment opportunities in the scheme and involvement in the urban garden proposal initially;

- Education levels are moderate with almost half the respondents having some high school education, but only 16% completed 12 years of schooling. This profile would well fill the requirement of manual labour which requires literacy and numerical competence;

- A fair amount of entrepreneurial activity was found in Daggafontein, especially among young people, and this could provide the recruitment base from which future managers are drawn;

- Residents were found to be committed to the area and would be participants in the ongoing development of the community;

- Local government structures at the Ward level were not found to be functioning optimally and require attention in maintaining communication with the community involved. The project will thus need to liaise and work closely with local government if it is to be accepted and to succeed, and this will need to be pro-actively and systematically developed, and a sound working relationship cultivated on an ongoing basis.

Indicators for potential success of the project have been summarised as follows:

- Available expertise to treat the polluted mine and sewage water;
- Sufficient treated water for hydroponic cultivation;
- Available land in the area for developing hydroponic cultivation;
- Potentially large amounts of semi-skilled labour in informal settlements and townships near Grootvlei Mine;
- Training resource and experimental facilities via ANCOR Sewage Works;
- Predominantly small-scale entrepreneurs in communities such as Daggafontein;
- Potential markets for vegetables in the surrounding townships, in the Ekurhuleni Metropolitan Municipality and in the Gauteng region;
- Supportive Response from officials at Ekurhuleni Metropolitan Municipality;

Indicators for potential failure or problems include:

- The capital-, management- and labour-intensive nature of hydroponic cultivation;
- Senior level administrative and financial management will have to be recruited from outside, therefore there will be a continuous 'top down' component to the project, with community members always being in only the more junior administrative positions;
- Need for "24/7" availability of labour;
- Strong rural component in the responses and behaviour patterns of many of the respondents interviewed;
- Limited effectiveness of current local leadership and local government structures at the Ward level;
- Inevitable political tussles when significant new resources are made available which could be severely disruptive in the context of local government structures that are still struggling to find their feet and operate effectively.

11.6 RECOMMENDATIONS

The study of the proposed Springs/Nigel SDI reported above has indicated an overall guarded optimism for successful outcomes based on the preliminary physical, technical, economic and social investigations reported here. Clearly this remains a first order assessment of feasibility and would require a much more detailed follow-up to provide the rigorous and detailed planning structure on which to proceed.

The following recommendations are thus made as a guide to follow-up steps that need to be addressed:

- The Springs/Nigel SDI would be a regional development programme and thus participative structures would need to be set up in which the local communities, local government, the EMM, the mines and ERWAT, DWAF, and Provincial and National Government may become involved;

- The preliminary report, as detailed here, provides a basis for initial discussions and the planning of future activities;

- Without prescribing how this programme may develop, a follow-up in-depth investigation will need to expand on the preliminary nature of the current report and generate a detailed bankable business plan underpinning the proposed development. This will need to include confirmation of physical and environmental resource estimates, mapping of the proposed agricultural use areas, revisiting market estimates, confirming sources of funding and constructing the business plan;

- The business plan will need initial green-lighting from EMM, and may be best managed by a programme co-ordinator who will need to facilitate a complex process of negotiations and iterations in bringing the idea to fruition;

- It is recommended that an NGO funding agency be approached to fund the business planning and the detailed scheme development phase, and that some level of autonomy exist here so that technical concept development does not get bogged down in the necessary, but possibly time-consuming, process of political interaction;

- Ultimately EMM will need to assume ownership of the scheme, but may decide to postpone that decision until the detailed study has been completed;

- The study reported here provides a model for comparable situations of mine closure both in South Africa and around the world. Thus given the wider ambit, donor funding should be sought from interested parties internationally to fund at least part of the proposed development as a case study for similar interventions required elsewhere.

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APPENDIX 1

TREATMENT OF HYPER-SALINE WASTEWATER STREAMS – THE *ATRIPLEX* SYSTEM

Alan Melville, Antonius Leucona
Public Domain Management
Johannesburg

1. INTRODUCTION

While the conceptualisation of the vegetable production system outlined above was based on the quality of the water which would be generated in the combined action of the Rhodes BioSURE Process® and dilution with final effluent from Ancor Works, it had also been identified at the outset that provision should be made for water released which would not be diluted or which might be generated in a membrane desalination operation, if that was the treatment option to be chosen by Grootvlei Mine. In this case the sodium and chloride concentrations would remain substantially elevated, and this saline stream would be more typical of the mine waters generated in South Africa that are exposed to Karoo system geological formations.

Pretreatment of the water in a high density sludge (HDS) operation, before passing to the Rhodes BioSURE Process® will clearly not meet the general discharge standard as shown in Table A1.1. This means that desalination of some form must be implemented to remove a minimum of ~170mg/l sodium and ~100mg/l chloride.

Table A 1.1: Analysis of Grootvlei minewater following HDS and BioSURE treatment but without dilution

Nutrient	Unit	Raw Grootvlei	HDS Treated	Post BioSure	Discharge Std
Na	mg/ℓ	239	239	239	70
Cl	mg/ℓ	184	184	184	80
SO4	mg/ℓ	1747	1688	<150	250

Since, at the conclusion of the technology evaluation exercise undertaken by Grootvlei Mine, the Rhodes BioSURE Process was selected as the technology of choice and dilution with Ancor waters was agreed, the work on the treatment of a hypersaline stream was no longer of direct relevance. However, the work undertaken on the Atriplex system holds real promise for other areas where saline minewaters waters will need treatment and thus the results of this study have been included here.

3. THE *ATRIPLEX* SYSTEM

Atriplex numeralia, or ‘Old Man Salt Bush’, is well adapted to growth in saline soils, and under a wide range of conditions has been shown to remove and accumulate salts from the feed water stream. Previous research undertaken by the authors has shown that the plant may be successfully grown in hydroponic systems in the Gauteng region, and in single pass configurations can be engineered to remove substantial quantities of sodium chloride salts.

Based on their previous research experience, and in consultation with other researchers in the field, it is proposed that in order to reduce the sodium chloride levels to acceptable discharge standards, a maximum of 15 ha of *Atriplex* under hydroponic cultivation would be required per Mℓ of treated minewater received.

This calculation is based on winter climate growth conditions, under open-field conditions – which present the most conservative uptake rate, as demonstrated in the previous Gauteng studies.

The salt-reduction potential is shown in Table A1.2.

Table A1.2: Sodium chloride removal in *Atriplex* hydroponic systems as Kg/ha/day per ML

Nutrient	Unit	Post BioSure	Kg/day Removal	15 ha – Kg/day Removal Rate	Balance Remaining	Compared to Std.
Na	mg/ℓ	240	12	180	63	- 7
Cl	mg/ℓ	184	10	150	34	- 46

In order for the current 10ML/day load of Grootvlei water to be treated, there is therefore a requirement for a minimum of 150 hectares of hydroponic system – using the aforementioned design criteria. It is proposed that a simple plastic lined open gravel channel system could be used without any protective coverage.

It should be noted that the surface area requirement is dependent on the type of system used, and could be quite dramatically reduced if a more sophisticated structure (e.g. plastic or shade cloth cover or a fully controlled greenhouse structure) is erected – but the capital cost will also then increase substantially. It is suggested, however, that the highest economic value added solution is most likely to be the simpler system and structure, as proposed here.

The capital cost of the proposed Atriplex system is estimated at R50 per square meter, or R500 000 per hectare. This cost estimate may be regarded as an approximate number, due to the unknown topographical issues, as well as other engineering considerations, such as pipeline length, pump requirements, and discharge routings. Further, this amount does not take into account any scale savings – of which there could be a substantial amount, as shown in Table A1.3.

The Net Present Value and Internal Rate of Return calculation, and the assumptions on which it is based, for an *Atriplex* system, as designed and proposed, are reported in Table A1.3.

Table A1.3: Net Present Value and Internal Rate of Return calculations for the *Atriplex* system.

Item	Per hectare cost	Per Unit Return	Comments
Capital Structure:			
500 micron plastic channels	140 000		Minus Scale savings
Gravel base for channels	132 000		Minus Scale savings
Pumps and Piping	88 000		Minus Scale savings
Earthworks	60 000		Minus Scale savings
Water Storage Capacity	30 000		Minus Scale savings
Computer Controller and valve controllers	25 000		
Other general items	25 000		
Fixed & Variable Agronomic Expenses			
Annual Agronomic Variable Expenses	30 000		Fertilisers, micro-nutrients, repairs
Annual Operating Expenses – Labour	48 000		1 Supervisor + 4 labourers
Annual Operating Expenses – Management	18 000		Consulting inputs
Atriplex Yield & Earnings			
Atriplex wet yield ton/ha – open field		20	Estimate ex previous studies & experience
Atriplex wet yield ton/ha – hydroponics		80	Conservative – could be substantially higher
Number of 22 kg Bales per tonne		45.45	22 kg is fodder norm
Number of Bales per hectare		3 636	
Lucerne price per Bale		R35.40	Ex Lichtenburg
Atriplex price per bale at 85% of lucerne		R30.09	Estimated return for wet material
Annual Earnings – 150 ha		R16 412 727	
Other Earning Potential – Water			
Daily Amount (Ml) of Beneficiated Water		0.5 Mℓ	Based on 50% uptake by plants

Daily Amount (Kℓ) of Beneficiated Water		500 Kℓ	
Clean water per Kℓ		R1.25	Conservative estimate
Daily Clean water Value		R625	
Annual Value – 150 ha		R2 187 500	350 day operation
Other Saving Potential – Pollution Management			
Daily Amount (Mℓ) of Polluted Water per hectare		1 Mℓ	
Daily Amount (Kℓ) of Polluted Water / ha		1000 Mℓ	
Polluted water fee per Kℓ		R0.25	Conservative estimate
Daily Polluted water Costs		R250	
Annual Value – 150 ha		R875 000	350 day operation
NPV Calculation			
Total Capital Cost	R60 000 000		Scale Saving applied
Annual Gross Earnings – Atriplex		R16 412 727	
Annual Costs – Atriplex	R9 600 480		Scale Saving applied
Annual Potential Value – Water		R2 187 500	
Annual Potential Value – Waste Management Savings		R875 000	
Discount Factor used		13.50%	Expected rate – Sept
NPV		R774 388.83	Before interest & taxation
IRR		14.30%	

4. ECONOMIC VIABILITY OF THE *ATRIPLEX* SYSTEM

The functionality, scale, affordability and long-term efficiency of the *Atriplex* system will be of primary concern to the mining operation – as they are required by DWAF to ensure that their discharge stays within the specifications, even after eventual mine closure.

The performance of the Atriplex system in the Grootvlei application may be summarized as follows:

Legal requirements

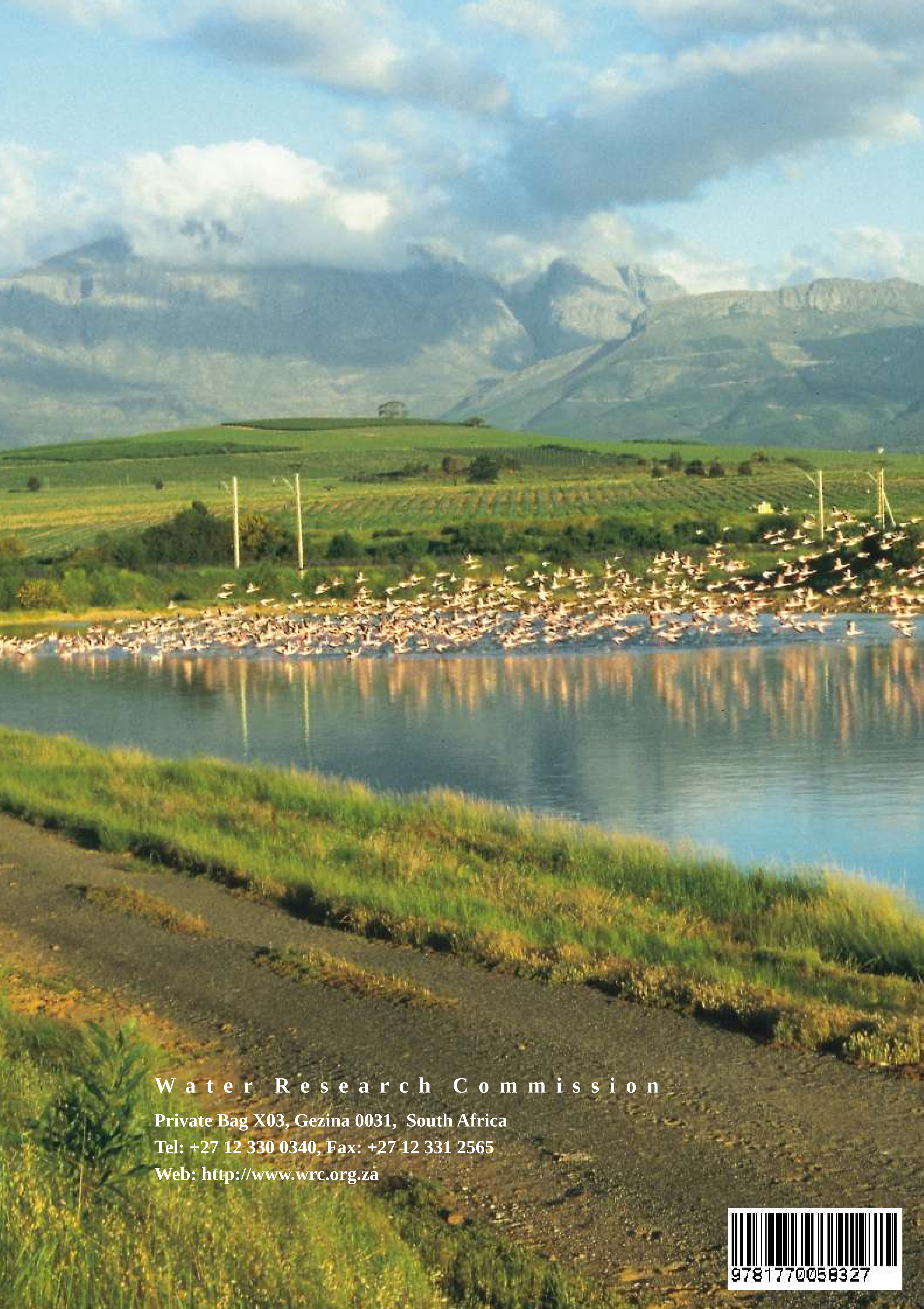
- Sodium is reduced from ~240 mg/ℓ to ~6 mg/ℓ, and thus falls within DWAF discharge specifications.
- Chlorides are similarly reduced to discharge specifications – from ~184 mg/ℓ to ~34 mg/ℓ.

Economic aspects

- The 150 ha total area required for the Atriplex system is NPV positive over a ten year period (applying a perpetuity factor of 4 and a discount rate of 13.5%), and the NPV of R774 388.83 indicates that the initial capital cost and long-term operating cost requirements may be sustainably recovered.
- The 150 ha system returns an IRR of 14.30% on the investment which is also not unattractive.
- A key driver of the positive NPV is the fact that the leaf matter from the *Atriplex* plant can be harvested and sold as a salt-enriched cattle fodder – either in a low-value wet baled form (on which these economic projections have been based) or with a little further processing, as a high-value pelleted stock feed. It is estimated that Atriplex could be sold at about 85% of the going price for Lucerne bales, in the wet form.
- A further key financial input is the value of the water after it has been treated by the *Atriplex* system. It is estimated that a minimum of 50% of the mine discharge water – which equates to 5 Megalitres per day – will be available for further downstream agricultural usage, which is in line with the Ekurhuleni Metropolitan Council's vision for an agriculture-based development node in this area. The value of this water (if sold as assumed in the model), has been valued at R1.25/ Kilolitre, which substantially discounts the going price for industrial water.
- Similar to the water recovery benefit, the fact that the mine will no longer need to actively manage the wastewater and/or incur discharge penalties means that savings can be generated in these areas. The financial model assumes that the full 10 Mℓ/day discharge will no longer attract costs and/or charges, resulting in a saving of R0.25/Kilolitre. It is suggested that this figure of R 875 000 per year is probably conservative.

Socio Economic Factors

- The 150 ha *Atriplex* system will create approximately 50 new sustainable jobs, of differing skills levels from farm labourer to supervisor level.
- As mentioned previously, *Atriplex* generates leaf matter that may feasibly be sold as cattle or other livestock fodder – especially in North-Eastern Gauteng and the adjacent areas of Mpumalanga where the predominant "rooigras" is salt-deficient.
- However, as an alternative, this leaf matter may be used for further value-adding purposes; namely to support a feedlot system for livestock – an initiative that would result in further job creation opportunity, poverty alleviation and malnutrition reduction amongst the neighbouring communities.



Water Research Commission

Private Bag X03, Gezina 0031, South Africa

Tel: +27 12 330 0340, Fax: +27 12 331 2565

Web: http://www.wrc.org.za

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