Analysis of the Financial and Economic Feasibility of Drainage in the Orange-Vaal-Riet and Lower-Orange Irrigation Areas

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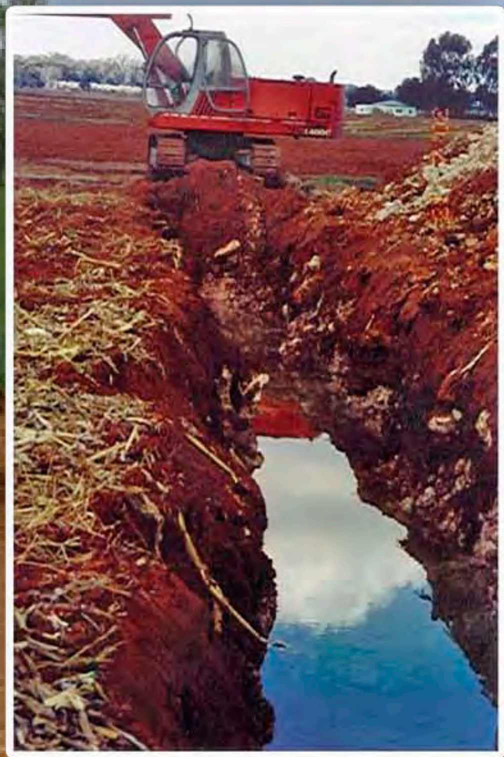

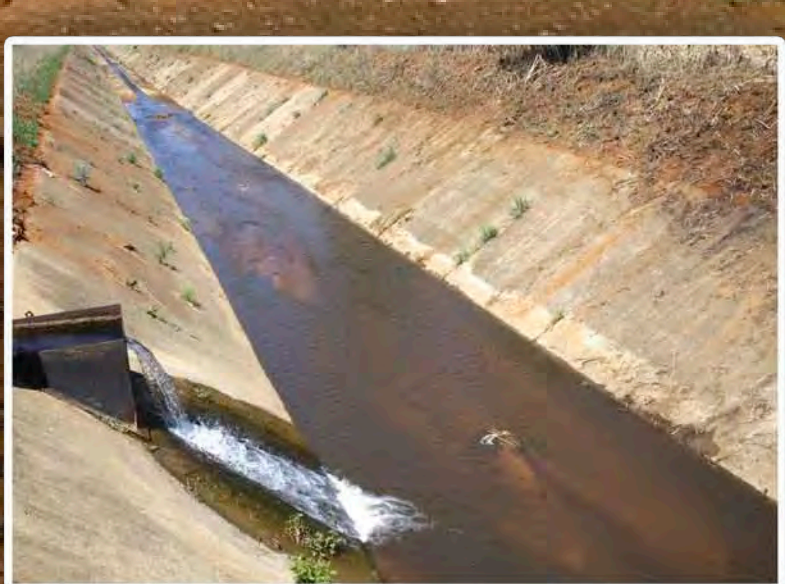

WATER RESEARCH COMMISSION

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Analysis of the Financial and Economic Feasibility of Drainage in the Orange-Vaal-Riet and Lower-Orange Irrigation Areas

Report to the

Water Research Commission

by

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EXECUTIVE SUMMARY

South Africa has limited soil suitable for irrigation (only about 1.2 million hectare, (DEAT, 1999)) and it is therefore important to preserve the potential of the soil and keep it in a sustainable production state. Salinity of irrigation soil has already become a major concern with about 15% of the country's irrigation soil waterlogged or saline (Van Huyssteen, 1995).

In order to address the salinity problem, research is conducted in the study area (the service areas of the Orange-Riet and Orange-Vaal water user associations) on how to handle/manage the problem. Based on already completed research, it was decided to enter into a phase of technology transfer by *inter alia* applying available models researched and reported in Viljoen *et al.* (2006) at case study farm level in the mentioned study area as well as in the Lower-Orange irrigation area. Besides transferring knowledge to farmers, interested parties and officials, the aim was also to aid in the development of guidelines for government assistance (e.g. sustainability grants) for irrigation drainage installation at farm level.

This report gives an overview of the technology transfer conducted and presents guidelines and suggestions for consideration at three levels: case study farmer, service provider and policy level. A brief overview of some of the findings/recommendations at these levels follows:

Case Study Farmer level

The policy mix that made all case study farms achieve a positive cash flow ending value with drainage installed and accounting for existing debt was a grant of 90%, bridging finance at 10% and debt financing at 12%. When not accounting for current debt, the grant can be reduced to 60% but the interest rates will also have to be subsidised to lower levels of 9% and 10% respectively for bridging finance and debt financing.

Service provider level

It is important that the various service providers coordinate and align amongst themselves to be relevant at meeting the farmers' needs by utilising the available policy incentives and by actively directing and influencing policy development. Various actions are suggested for the different service providers involved in drainage planning, installation and financing.

Engineers - There is a drastic shortage of suitably trained irrigation engineers in South Africa to sustainable implement a large-scale drainage programme. This will require serious action in providing incentives (bursaries) for young professionals and more attractive packages within the state departments to attract and keep irrigation engineers.

Banks - Financing of re-establishment of perennial crops and/or drainage will generally be done through the commercial banks. As these require large capital expenses thorough and realistic projections need to be made. Banks should be careful of granting loans on farms that are becoming water-logged / salinised without the capacity for corrective actions. If funding is needed to establish a perennial crop, the salinity tolerance of the crop needs to be matched with that of the irrigation water supplied and that in the soil.

WUAs - WUAs have an important role in coordinating drainage and leachate disposal options amongst farmers.

Input suppliers - Fertilizer companies:

- Should take regular soil samples to ensure the correct nutrients are applied.
- When analyzing these soil samples ECe is usually determined. This is important information that can be entered into the soil salinisation database. Important however to note is that this information can be further enhanced if geo-referenced and samples are taken form the same site annually to determine ECe trends over time.
- Where farmers are using saline irrigation water it is important to understand the effect on liquid fertilizers.
- Furthermore, as these farmers will have to leach out the salts, the fertilizer companies will have to recommend fertilizers that do not readily wash out of the soils with leaching.
- Where sodification has taken place in soils it is important that fertilizer companies recommend the correct lime / gypsum to correct the SAR.

Input suppliers - Co-operatives / agribusinesses:

- The co-operatives / agribusinesses need to continue to provide irrigation scheduling services and to expand these to all members as these go a long way to prevent water-logging resulting from prolonged over-irrigation.
- The co-operatives / agribusinesses already provide precision agricultural services to a limited paying clientele; this information is very valuable in identifying the areas with lower yields and analyzing them further to determine the specific reasons of the reduced yields.

Policy level

Policy options are suggested to facilitate the installation of drainage for effective salinisation and water-logging control to increase agricultural production and hence socio-economic welfare. These are included in the Recommendations:

Serious and concerted local action is required to further identify and raise the awareness of the salinisation and drainage threat; and political action and support is urgently needed to help curb further resource degradation through drainage, and to regain the productivity of already salinised and waterlogged areas. This can be achieved through *inter alia* drainage grants, debt consolidation and subsidised bridging finance mechanisms for existing debts and additional drainage financing costs. An effective data measurement, analysis and communication programme together with local suitably trained irrigation service providers and technicians are also required as precursors for effective implementation and evaluation.

The following are the main actions recommended from this consultancy:

"Green box" drainage grants

The economic models concluded that drainage is economically viable in many situations for salinity and water-logging management. The financial models however concluded that, although economically viable, unless the farmer has no initial debt, drainage is not financially feasible. Furthermore, awarding a drainage grant was necessary to incentivise most farmers to drain.

Debt consolidation and subsidised interest rates

In some cases a drainage grant alone was not sufficient, nor as effective as a policy instrument as subsidising the repayment interest rate of the loan. In the worst case study the only way that the farmer could continue farming and remain financially feasible was if his current debt, together with re-establishment and drainage costs were consolidated and repaid at a subsidised interest rate.

Monitoring and data

Water-logging and salinity data collection, population of a database and an effective communications programme was agreed to be necessary at all the meetings with farmers and service providers. Unfortunately the simplified farmer level methodology used and presented was turned down as it was agreed that most farmers wouldn't have the time to do it, although they were interested in having the information. The developments of the Department of Soil Science at the UFS's current project in commercialising an EM38 ECe mapping device for an Oppermansgronde entrepreneur was mentioned and received with optimism.

Training for Irrigation service providers and technicians

The important role of WUAs for scheme level drainage management was realised and their need for support, training and personnel. In all the farmer and service provider meetings it was mentioned that there is a desperate shortage of trained irrigation service providers and technicians to assist with drainage planning and monitoring of salinity and water-logging.

Although the main technology transfer took place at farmer, service provider and policy maker workshops, the report concludes with a list of other published technology transfer actions such as conference presentations and academic and popular journal articles.

Further detail on model use and a more in-depth analysis of the case study farms can be found in the appendices.

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LIST OF ACRONYMS AND ABBREVIATIONS:

Tiers of Government and other institutions:

CCAW	Co-coordinating Committee on Agricultural Water
CSIRO	Australia's Commonwealth Scientific and Industrial Research Organisation
DBSA	Development Bank of Southern Africa
DEAT	Department of Environmental Affairs and Tourism
DWAF	Department of Water Affairs and Forestry
FS-DoA	Free State Department of Agriculture
GWK	Griqualand Wes cooperative
ICID	International Commission on Irrigation and Drainage
IWMI	International Water Management Institute
NC-DoA	Northern Cape Department of Agriculture
NDoA	National Department of Agriculture
NEPAD	New Partnership for Africa’s Development
WRC	Water Research Commission

Regional identifiers:

CSF	Case Study Farm
LO-CSF	Lower Orange Case Study Farm
LO-WUA	Lower Orange Water Users Associations
OR-CSFc	Orange-Riet Commercial Case Study Farm
OR-CSFe	Orange-Riet Emerging Case Study Farm
OR-WUA	Orange-Riet Water Users Association
OV-CSF	Lower Vaal Case Study Farm
OV-WUA	Lower Vaal Water Users Association
WUA	Water Users Association

Financial terms:

B/C	Benefit Cost Ratio
B:C	Benefit Cost Ratio
BCR	Benefit Cost Ratio
CEB	Crop Enterprise Budget
GGP	Gross Geographical Product
GM	Gross Margin
GMASC	Gross Margin (GM) Above Specified Costs
IRR	Internal Rate of Return
NPV	Net Present Value

Other:

ASGISA	Accelerated and Shared Growth-South Africa
BankMod	Repayment ability model
CASP	Comprehensive Agricultural Support Programme
DRAINFRAME	Drainage Integrated Analytical Framework
ECe	Electrical conductivity of saturated soil extract
ECiw	Electrical conductivity of irrigation water
FinData & Fin Analysis	Financial Analysis Model
GPS	Global Positioning System
HDI	Historically Disadvantaged Individual
LARP	Land and Agricultural Reform Policy
PVC	Polyvinyl Chloride
SALMOD	Salinity and Leaching Model
SAR	Specific adsorption rate
SBC	Serial Biological Concentration
SMCEBs	Direct Profitability Model
SMsim	Salinity simulation Model
TDS	Total dissolved solids
WDC	Waste Discharge Charge
WMA	Water Management Association

1. INTRODUCTION.

In the light of national and global food security, water-logging and salinisation of irrigation land (of which South Africa has a limited quantity) poses a serious threat to 50% of this sector that produces 40% of our national food. This justifies continued concerted action by Government and the community to address the threat of increasing salinity and water-logging and their impacts.

This report demonstrates the financial implications of the strategic activities that will achieve results to rehabilitate affected areas and prevent further water-logging and salinisation on existing irrigated areas. With land redistribution being a priority, not to do so would be at the expense of food production, by settling new inexperienced irrigation farmers on unsustainable land where they will be demoralised.

The salinity problem is serious and so difficult to manage that careful consideration must be given to the application of public and private resources to its management. In particular, increased activity for the development of commercially viable options and business enterprises to assist farmers and regional communities to more effectively manage salinity is recommended. This will mean a different approach to Government funding involving targeting public investment to promote private action and investment in the form of Green Box grants (e.g. the commercialization of a salinity mapping business for Oppermansgronde beneficiaries). It should also materially help the Government in negotiating partnerships with NEPAD / ICID / IMWI to be leaders in addressing this problem that affects 20% of Africa. The resulting coordinated and visionary approach to jointly develop integrated solutions to salinity should bring considerable benefits to rural communities.

Apart from developing commercially viable options to manage salinisation and water-logging, developing the capacity of individuals (irrigation service providers / technicians) and communities (WUAs) to respond is also a central concern. The need is therefore argued for increased investment in the development of new technologies (especially drainage and data collection and monitoring), increased and improved extension services and stronger institutional arrangements including the role of natural resource management regional groups (i.e. the local WUA's, LandCare, etc.).

Appreciation must be mentioned for the support and level of enthusiasm within the communities to contribute to this research over the last 3 years. Presentations were made at 5 DoA and DWAF meetings and 6 public meetings which were attended by more than 150 people. The level of engagement clearly demonstrates the far-reaching impact of salinity on the lives and businesses of many in the Orange-Vaal, Orange-Riet and Lower-Orange communities and the genuine commitment of people to continue looking for solutions and to take action. Increasing financial pressures coupled with a deteriorating resource base is placing many important food producers in a precarious position, whether commercial or historically disadvantaged.

Of the four case studies, investigated from farmer-to irrigation service provider-to policy level, three were commercial farms and one a Land Reform farm. This research document makes various recommendations to the Government for consideration. While it is hoped that this report and recommendations will shape salinity management in the Lower -Vaal, -Riet and -Orange River Areas and beyond in the coming years, we also urge the need for periodic review to ensure that the State is responding to new information and new opportunities as they become available.

To further orientate and guide the reader this chapter contains:

a. A review of the consultancy aims.

b. WRC salinity and drainage research in the study areas over the last 10 years.

c. A brief answer to the question the question; “why is salinisation and water-logging a problem?”

d. An overview of the extent of the problem.

e. A suggestion that effective drainage is the solution to salinisation and water-logging, and

f. Report layout

1.1 Review of the consultancy aims

The general objective of this study was to apply available models developed in Viljoen *et al.* (2006) at case study farm level in the two study areas of the Orange-Riet/Orange Vaal and Lower-Orange irrigation area, to aid in the development of policy guidelines for government assistance (e.g. sustainability grants) for irrigation drainage installation for sustainable national resource protection and conservation.

The six specific objectives of the technology transfer exercise were:

a. To present the results of the existing study to the National, Free State (FS) and Northern Cape (NC) Departments of Agriculture (DoA) to get their buy-in, co-operation and support for the application of the developed economic models to case study farms with salinity problems in the OVR and Lower-Orange Irrigation areas

b. To hold information sessions/workshops with DWAF, the Orange-Riet and Orange-Vaal WUAs, Agri-businesses (e.g. GWK Pty.Ltd.) and farmers to explain the findings of the current study and to get practical pointers for the farm level analysis to follow.

c. To apply the developed economic models to identified case-study farms in the already researched study areas for farm level drainage feasibility analyses.

d. To adapt (mainly for viticulture) and apply the developed economic models to identified case-study farms in the additional study area of the Lower-Orange Irrigation region for farm level drainage feasibility analyses.

e. To present the results from the additional Technology Transfer Study (case-study farm specific) to farmers, Water Users Association (WUA) staff, government and agribusiness officials / extension officers, and irrigation research professionals through farmer’s day presentations, brochures and the internet.

f. To compile a user friendly technology transfer report

To address these six aims/objectives, six deliverables were prepared through the course of the consultancy and were addressed in the form of four reports:

a. Communication of results to DoA and to hold stakeholder workshops to share the WRC report (Viljoen *et al.*, 2006) results and to prepare for further farm level analysis (***Workshops and Presentations report***)

b. Development and application of models to already researched and additional irrigation areas (***Models report***)

c. Technology Transfer meetings and feedback (***Meetings Report***)

d. Technology Transfer Final Report

1.2 WRC salinity and drainage research in the study area over the last 10 years

The following is a chronological list of WRC research reports depicting the history and direction of salinity related research in the study area over the last 10 years:

DU PREEZ, C.C., VAN RENSBURG. L.D. BENNIE, A.T.P. *et al* (2000) Effects of Water Quality on Irrigation Farming along the Lower Vaal River: The Influence on Soils and Crops. WRC Report No. 740/1/00, Pretoria.

ARMOUR, R.J. & VILJOEN, M.F. (2002) The Economic Impact of Changing Water Quality on Irrigated Agriculture in the Lower Vaal and Riet Rivers. Water Research Commission Report No.947/1/02, ISBN No. 1-86845-951-9

VOLSCHENK T., FEY M.V. & ZIETSMAN H.L. (2005) Situation Analysis of Problems for Water Quality Management in the Lower Orange River Region with Special Reference to the Contribution of the Foothills to Salinisation. WRC Report Number: 1358/1/05, Pretoria

VILJOEN, M.F., ARMOUR, R.J. *et al* (2006) Multi-dimensional Models for the Sustainable Management of Water Quantity and Quality in the Orange-Vaal-Riet Convergence System. WRC Report No. 1352/1/06, ISBN No.1-77005-486-3

ARMOUR R.J. & VILJOEN M.F. (2008) Analysis of the Financial and Economic Feasibility of Drainage in the Orange-Vaal-Riet and Lower-Orange Irrigation Areas. WRC Project K8/703

VAN RENSBURG L. *et al.* (forthcoming - 2009?) Managing salinity associated with irrigation in selected areas of SA. WRC Project K5/1647

1.3 Why is salinisation and water-logging a problem?

The build-up of salts (salinisation / “*verbrakking*”) and rising water-tables (water-logging / “*versuiping*”) in irrigation lands poses a serious threat to future national food security, and results in the unproductive use of our precious water resources. The irrigation agriculture under threat by these resource degrading processes plays a vital role in supporting the socio-economic existence of the rural communities built around irrigation. Salinisation and water-logging not only threat commercial irrigation farmers, emerging irrigation farmers and their workers, but whole communities as well as national food security.

Salinisation was the demise of the ancient Mesopotamian civilisations, the reason for the collapse of the entire economy of Aral Sea basin in Kazasikstan, etc. Let not history repeat itself. In South Africa the Fish and Sundays Irrigation Schemes suffered due to salinisation before the Orange-Fish canal brought fresh water. The Breede River in the Western Cape is also experiencing salinity problems as well as the Vaalharts irrigation scheme where water-logging also threatens to name a few problem areas in South Africa. This report however only deals with the Orange-Vaal, Orange-Riet and Lower-Orange Water User Association case study farmers to demonstrate water-logging and salinisation management options at farm, service provider and policy levels. The basic principles and models described in this report however can be widely applied.

Johnston (1994) warned that "*most of the irrigation schemes in South Africa are affected to some degree by soil salinity. This accumulation of salts in the soil is normally associated with water-logging that occurs primarily in the poorly- drained regions of the landscape. Salinisation usually develops insidiously over many years, and can present a serious threat to the long-term viability of an irrigation scheme. There is a need therefore to monitor trends in soil salinity levels on irrigation schemes.*" Not heading to this warning by Johnson (1994) made over 14 years ago, there is currently still no soil salinity monitoring process initiated and thus no reliable data on soil salinity trends.

1.4 The global and local extent of the problem

Globally, salinisation is advancing at 3 hectares of irrigation land per minute or 1.5 million hectares per year. Currently, 20% of globally irrigated land is affected by salinisation (Wood, 2008).

Table 1.1. Global extent of human induced salinisation (Wood, 2008)

Continent	Light (M ha)	Moderate (M ha)	Strong (M ha)	Extreme (M ha)	TOTAL (M ha)
Africa	4.7	7.7	2.4	-	**14.8**
Asia	26.8	8.5	17.0	0.4	**52.7**
South America	1.8	0.3	-	-	**2.1**
North & Central America	0.3	1.5	0.5	-	**2.3**
Europe	1.0	2.3	0.5	-	**3.8**
Australia	-	0.5	-	0.4	**0.9**
TOTAL	34.6	20.8	20.4	0.8	**76.6**

Table 1.1 shows that Africa is the 2nd most salinised continent after Asia and Africa and Asia together account for 90% of the world's salinisation problems (Wood, 2008). These two continents are also the two where hunger and food insecurity are also greatest. About 80 million hectares in Africa are deemed to be saline, sodic or saline-sodic (Taha, 2008).

The National State of the Environment Report (DEAT, 1999) lists the following facts cited form other authors:

Of the of 1,2 million ha of irrigated land in South Africa,

a. 10% is affected by water-logging (Scotney, 1995)

b. 10% is severely affected by salinisation; 54 000 ha severely 128 000 ha moderately affected (Laker, 1994)

c. 15% is affected by water-logging and salinisation together (van Huyssteen, 1995).

In the study area Van Heerden *et al*. (2001) shows that in 2001, 10% of the land in the Orange-Vaal Water Users Association (**OV-WUA**) region was already severely affected and a further 13% slightly affected by salinisation, totalling 23%. Further citing Van Heerden *et al.* (2001), of the 8075 hectares allocated for irrigation in the OV-WUA, only 51% is classified as high potential irrigation land, 36% as medium potential and 13% as low potential. 51% therefore of the OV-WUA shouldn't have drainage problems or salinity problems if leaching is practiced. The other half of the scheme is potentially under threat of which a quarter (23%) is already showing signs of salinisation.

The Orange-Riet Water Users Association (**OR-WUA**) covers a total area of 16 771,3 hectares. No literature is available on the exact extent of salinisation and water-logging in this area. Since the completion of the

Orange Riet Canal whereby Orange River water is pumped into the Riet River, many of the problem areas that existed improved due to the better quality Orange River Water. Downstream of the main Riet River Scheme near Jacobsdal, in the Lower Riet River, some of the worst salinity readings are however recorded. Although land irrigated with this water is generally well drained, yields are not as high as those achieved upstream on the scheme or downstream where a mixture of Vaal and Orange River water is used to irrigate with. On the scheme water-logging is occurring due to poor irrigation scheduling (over irrigation), rising water tables, expansion of evaporation ponds, speculated leaking canals and up gradient farmers affecting their lower-lying neighbours. Periodic high rainfall event and floods exacerbate these effects.

In the Lower Orange WUAs (**LO-WUAs**), between Boegoeberg and Onseepkans, Volkschenk *et al.*, 2005 conclude that it is estimated that grapevines and orchards are cultivated on 17 573 ha of land, while other crops utilize a total of 8 270 ha of land (grapevines 68%). Approximately 1.7% of the total sampled area was actually salinised (too saline for grapevine production without yield loss; i.e. soils had a saturated soil water extract EC > 0.75 dS/m) which amounts to 436 ha of soil for the whole area of 25 843 ha under cultivation in the Lower Orange River. The identification of salinised areas by means of the aerial survey approach was not very successful as only 14.3 % of the potentially salinised area was actually salinised. The limited success of this method is ascribed to the fact that vegetation stress is caused by numerous other local conditions such as stony, sandy or water-logged soils. Although the Lower Orange receives good quality irrigation water from the Orange River, the evapo-transpiration is much higher than in the Upper Orange and irrigation quotas are set at 15 000 cubic meters per hectare. With the greater water volume applied, a greater salt mass is also applied on the soils than in the OR-WUA where smaller volumes are applied. This can lead to a faster rate of salinisation in this more arid region than in the OR-WUA.

What the aerial work by Volschenk *et al* (2005) indicated is that only 14% of the area displaying poor growth (potentially salinised area) was actually saline. This indicates that vegetation stress on about 2000 ha in the lower Orange River area was induced by causes other than salinity, such as water deficits and localized water-logging. Based on these results, technology transfer regarding irrigation scheduling and water table management at farm level also appeared to be essential.

1.5 The solution to salinisation and water-logging: Drainage

The installation of irrigation drainage is in most cases a remedy to both salinisation and water-logging, but it is very costly, technically demanding to do right, and with implications for discharge of drainage return flows. This technology transfer document aims at addressing the economic viability and financial feasibility of irrigation drainage at case study farm level, regional service provider level and policy decision level.

Effective drainage can only work where the soil structure is conducive to the passage of water. Soils that have become compacted, stripped of organic material and/or sodic through poor management, first need to be remediated before effective drainage can take place. This is however outside of the scope of this report, but important to acknowledge.

A definition of drainage by Van Steenbergen (2003) at the 9th ICID International Drainage Workshop reads: *"Drainage consists of the processes of removing excess surface water and managing shallow water tables - by retaining and removing water - and of managing water quality to achieve an optimal mix of economic and social benefits while safeguarding key ecological functions."*

In this report drainage is referred to specifically as the physical infrastructure installed to remove the excess water, namely slotted PVC pipes installed sub-surface with a layer of filter media (stone/sand/cloth) deposited around it. The holistic definition by Van Steenbergen (2003) however is very important as it includes the management aspect that drainage enables, not only on farm, but on society and the environment through downstream and groundwater / water-table externality effects.

Many countries according to Wichelns (2002) invest public funds in large-scale drainage projects to alleviate problems of water-logging and salinisation, and to enhance agricultural development. The estimated returns on those investments are substantial when crop yields are expected to increase significantly with drainage service. A word of warning however by Wichelns (2002): if the need for drainage is caused largely by inadequate water management (i.e leaking canals, poor irrigation scheduling resulting in over irrigation, etc.), then the efficient strategy for enhancing agricultural productivity will include investments both in irrigation and drainage facilities and in policies that motivate improvements in water management.

1.6 Report layout

This technology transfer report consists of the following seven sections / chapters:

1. An introduction to salinity and drainage
2. A description of the method followed in conducting the technology transfer process to address the aims
3. Farm level actions and costs
4. Service provider level actions to help farmers and policy makers
5. A policy level proposed strategic action plan
6. Summary and conclusions
7. Appendices listing the more detailed back ground research and research progress of which this report is a summary

The chemistry, physics and hydrology of salinisation and water-logging are complex processes and therefore this report only focuses on the main drivers from these disciplines that are used in the calculating the economic impacts and the decision as to whether to drain or not to drain.

2. TECHNOLOGY TRANSFER PROCEDURE AND FEEDBACK

This chapter briefly outlines the technology transfer procedure and feedback, followed by the literature review that led to the setting up of the drainage financing models used in this consultancy.

2.1 Aims 1 & 2: Presentation of Project results and buy-in for further analysis

This aim was addressed in the first deliverable report, Workshops & Presentations Report, by the following Technology Transfer actions, namely:

a. Presentation of the results of the WRC report (Viljoen *et al.*, 2006) to the National, Free State (FS) and Northern Cape (NC) Departments of Agriculture (DoA) to get their buy-in, co-operation and support for the application of the financial models to case study farms with salinity problems in the Riet, Lower-Vaal and Lower-Orange irrigation areas.

b. Information sessions/workshops held with DWAF, the Orange-Riet and Orange-Vaal WUAs, Agri-businesses (e.g. GWK Pty.Ltd.) and farmers to explain the findings of the current study and to get practical pointers for the farm level analysis to follow.

The main results of the WRC report by Viljoen *et al.* (2006) conveyed at the meetings and workshops were:

a. The study showed that generally higher value (greater profit margin) crops are also the more sensitive crops to salinisation, and that draining is a better option economically than planting more salt tolerant crops such as wheat and cotton.

b. Where water-logging is present, changing crops isn't really an option and drainage is mostly the only solution. Water-logging is also a precursor to salinisation as it provides a vector for salt to dissolve and migrate and accumulate in the soil surface, exacerbating the salinisation problem.

c. From a salinity perspective (excluding water-logging), drainage is only economically viable in the worst affected area, namely the Lower Riet River.

d. Although economically viable (positive incremental Gross Margin), farmers in this area may not have the financial capacity to loan the capital required for the installation of drainage

e. In the other irrigation areas, salinity alone (excluding the effects of water-logging) is causing potential losses (as modelled – not actually quantified), but the financial value of these losses are less than the capital repayments to repay a loan to install drainage to remedy the losses, and thus economically not viable for farmers to install

f. To the regional economy however these losses are substantial, especially when factoring in the secondary and value adding effects throughout the value chain from producer to consumer in terms of gross geographical product (GGP) and job losses.

g. The nature of salinisation is that it is not static (or in equilibrium), it builds up over time, and sometime or other in areas where it wasn't economically viable to drain, it will be once salts reach a certain threshold.

h. With increasing pressure to use water sparingly (more crop per drop) and better technology (centre pivots) and management capacity available (scheduling services), farmers are irrigating very efficiently, and no longer accidentally leach out the salts in their soils by over-irrigating. This leads to an increased risk of salinisation if occasional high rainfall / flooding events don't leach out enough salts naturally. These high rainfall / flooding events may help with natural salinity control, but if the soils aren't suitably drained, they also contribute to water-logging.

i. The installation of sufficient artificial drainage is therefore and ideal solution to both water-logging and salinisation, however, careful biophysical and economic planning is necessary.

More specifically, the following figures from Viljoen *et al.* (2006) were also presented making an economic case for support for salinisation and drainage control:

a. The total regional output generated under base-case conditions in 2005 amounts to R 804.37 million. With increased drainage this total regional economic output can be increased to R977 million, an improvement of R173.63 million in one year alone

b. The total once off costs of additionally leaching 20% more in Lower Riet area of the OR-WUA, 10% more in OV-WUA and 5% more in the rest of the OR-WUA only amounts to R 64.75 million.

c. The full grant assistance of these costs can be justified in just 7 years if not taking the time value of money into account and not taking into account the improvement in the regional economy.

d. Over 15 years R 995 million in potential agricultural returns is cumulatively lost in the study area due to salinity alone (with all other factors of production assumed optimal)

e. A total GGP value lost to the regional economy of R10 million per year when farmers having to pay for the additional drainage costs themselves

f. When considering the indices for sustainable economic welfare (ISEW) in Viljoen *et al*., 2006, it is evident that scenarios modelled that include drainage have a steeper improvement in the overall levels of sustainability than scenarios where drainage isn't implemented.

The above facts present a good case for grant assistance of additional irrigation drainage in the interest of increased regional socio-economic welfare.

The following key results stemmed from the various meetings during the consultancy:

This first phase of the technical transfer process succeeded in raising the awareness of the results of the completed WRC report. It has informed the key stakeholders of the further plans of developing a financial farm level model, and has successfully obtained the buy-in of these stakeholders for the further developments.

Meeting interaction and feedback with the stakeholders resulted in important strategies for the farm level financial model development, namely:

1) Slotting into a farmers day as a separate item to a diverse audience doesn't work as well for communicating salinity and drainage issues as holding a possibly smaller, focussed workshop with selected participants. For the next round of meetings it was therefore decided to rather target extension officers and industry stakeholders / service providers (drainage installers, financiers, input suppliers, extension officers, etc.) to operate the farm level model instead of the farmers themselves

2) The farmers only need to be made aware of the results of the farm level models, with care to choose case study farmers that are known by the farmers. This was done and case study farmers were been identified and approached for each study area.

3) The most effective means of reaching the farmers is to write articles in the local print media (newspapers) and weekly magazines.

Because of *inter alia* the stabilising impact on national food security by irrigation produced food and the job creation potential in otherwise very marginal agricultural areas of the country, high capital investments are made in irrigation schemes leading to whole irrigation based industries and communities. If and when these schemes become unsustainable due to initially unforeseen events, such as salinisation, the socio-economic and environmental impacts could be disastrous. Salinisation at field level is however easily remediable, although it is also costly. As salinisation occurs slowly over time, by the time a farmer realises he has a problem, he has already suffered financial losses over a number of years, often placing him in a financial situation where he cannot raise the financial capital required for drainage without state assistance.

The aim of the next section is to discuss the financial models that can determine the level of financial assistance required by the farmers.

2.2 Aims 3 & 4: Economic Models for annual crops in the Orange-Vaal and Orange-Riet WUA areas and an additional model for the Lower Orange River for perennial vine crops

These aims were addressed in the combined second and third deliverable report, Models Report, by the following Technology Transfer actions, namely:

a. The application of the developed economic models to identified case-study farms in the already researched study areas for farm level drainage feasibility analyses.

b. The adaptation (mainly for perennial viticulture) and application of the developed economic models to identified case-study farms in the additional study area of the Lower-Orange irrigation region for farm level drainage feasibility analyses.

The developed economic models required considerable modification to determine financial feasibility at farm level. To take out the very specific spatial and temporal dynamics of the models developed in Viljoen *et al* (2006) so that the models could be applicable with ease by farmers and technicians to different areas, using basic data, many simplifications and assumptions had to be made.

Initially a complex suite of models was developed, the set up and results of which are presented in Appendix 3 to Appendix 6. As this suite of models was not user friendly and it was concluded that neither farmers nor service providers would use them, it was decided to go with a more simplistic approach. The tailored models that were developed were classed into farmer, service provider and policy level models.

The following key conclusions stemmed from the model design process:

a. Identified from interviews with stakeholders, water-logging is a far greater motivation for drainage than salinisation as farmers are more aware of the effects of water-logging than the subtle effects of salinisation.

b. The case study farmers selected were not farmers with the worst salinisation problems, but farmers whose irrigation practices and financial situation are relatively well known in the community so that farmers considering drainages would be able to relate their situation easily to these farmers.

A suite of models was developed to meet the dual aims of determining farm level profitability for commercial bank financing versus / in conjunction with a standard set of criteria for fair and equitable state grant support funding, namely:

- Direct profitability (SMCEBs)
- Repayment ability (BanKMod)
- Financial analysis (FinData & FinAnalysis)
- Stochastic (bio-physical Risk) analysis (SMsim)

These models are all linked so that when a full analysis is done, data is only filled in once and linked to wherever it is needed; but each model can also function as a stand-alone technology transfer / demonstration model (see Appendix 4 to Appendix 6).

The scenarios compared in the financial analyses are continuing from status quo conditions (no drainage), to a scenario of planting the same crops but with some additional drainage and another scenario of changing cropping composition to higher value crops on additional land with drainage installed.

It was however realized that one cannot plant higher value permanent crops on drained land near the river where the risk of flooding is high, reducing the direct profitability / repayment ability of drainage on such lands.

Results indicated that with the high costs of bank financing (17.25% effective interest rates) that the OV-CSF would not be in the same/better financial position with drainage as without it in 20 years, without a grant of up to 50% of the full drainage costs.

For the OR-CSF soil salinisation values alone barely affect crop yields resulting in the additional costs of drainage only increasing production and fixed costs without improving gross crop income. Incorporating the losses due to water-logging however, could make drainage feasible where no other irrigable land is available. Tax management incentives can also promote seemingly unjustifiable expenditure on drainage, but this does ensure the long term sustainability of the resource base and reduce the risk of water tables rising, water logged conditions and flooding.

Results in Table 2.1. summarise the results form the three CSFs. The OV-WUA CSF achieves negative NPV when continuing with low value lucerne on the newly installed drainage; if he plant more high value dry-beans and onions on the drained land he would achieve a positive NPV at discount rates below the IRR of 18.76%.

Results for the OR-CSF show that it is not feasible to drain for salinity management alone (not factoring in water-logging), and that planting barley as a higher value crop on the newly drained soils would perform worse than the current cropping combination.

Table 2.1. A summary of Financial Analysis results (NPV & IRR) for the three case studies

	OV-WUA CSF			OR-WUA CSF		
		NPV	*IRR*		*NPV*	*IRR*
Discount rate	**0.00%**	**17.25%**		**0.00%**	**17.25%**	
AD minus SQ	-672 135	-870 061	#NUM!	-2 577 246	-758 522	#DIV/0!
AD+ minus SQ	3 363 815	76 154	18.76%	-4 418 274	-1 194 771	#DIV/0!
Benefit Cost Ratio						
AD minus SQ	0.43	0.12	#NUM!	-14.88	-3.07	#DIV/0!
AD+ minus SQ	1.98	1.05	1.00	-3.56	-3.07	#DIV/0!

	LO-Area CSF (*Rscm*)			LO-WUA CSF (RloR)		
		NPV	*IRR*		*NPV*	*IRR*
Discount rate	**0.00%**	**17.25%**		**0.00%**	**17.25%**	
AD minus SQ	-1 215 865	-1 303 380	#NUM!	4 462 015	91 552	18.6%
AD+ minus SQ	206 412	-966 359	1.16%	5 867 689	416 819	23.0%
Benefit Cost Ratio						
AD minus SQ	0.25	0.06	#NUM!	3.62	1.07	1.00
AD+ minus SQ	1.12	0.31	1.00	3.62	1.29	1.00

The bottom half of Table 2.1. contains the results of the financial analysis of two scenarios for the LO-CSF, namely one using the Orange-Riet Scheme sub-WUA ECe sequence of soils water quality analysis results (as the farmers' irrigating from the Orange Riet canal use Orange River water), and one scenario receiving using Lower Riet ECe values as these are the highest recorded in the WRPM analysis, and most probably better fitting the actual situation at Friarsdale as reported by Volschenk *et al* (2005).

Results clearly show that with scheme soil water quality it is not feasible for the farmer to install drainage as the NPVs are negative for current cropping compositions and only positive with all land planted to higher value vines at a very low discount rate of 1.16% (=IRR). With Lower Riet simulated water quality however it is highly feasible to install drainage as the farmer has high NPVs and IRRs higher than the bank discount rate of 17,25% for installing drainage. The B/C ratio are also very favourable, above 3 with a 0% discount rate and just over 1 with a 17.25% discount rate for both scenarios.

For salinity control alone, the OV farmer could pay for his drainage (providing the banks will loan him the capital) only if higher annual value crops were planted. Long term crops would not be viable due to the position close to the rivers edge within 1 in 10 year flood lines. It is not feasible for the OR-WUA CSF to install drainage solely for salinity control, and especially not when planting barley on the newly drained soils.

In the Lower Orange area, at Scheme ECe soil water quality values it is not viable to install drainage for salinity control, and if higher value crops are planted, only at a very low discount rate. With Lower Riet ECe values the LO-Area CSF achieves high NPVs and an IRR of 18.6% from draining on existing crops; and for vines alone an IRR of 23%.

Results therefore show that where the ECe is high it is economically feasible to drain for salinity management, however financially the farmer may not have the creditworthiness to get a loan to install the drains. In the OV higher value crops will have to be planted, but where ECe's reach Lower Riet levels installing draining on existing crops for the LO-Area CSF proved feasible, possibly because he already plants a high percentage of higher value crops.

2.3 Aim 5: The compilation of technology transfer material from the results of the models and presentation to key stakeholders for comment and review

This aim was addressed in the combined forth and fifth deliverable report, Meetings Report, by the presentation of the results from the additional case-study farm specific analysis's to farmers, Water Users Association (WUA) staff, government (DoA & DWAF) and agribusiness officials / extension officers, and irrigation research professionals through presentations / workshops, and the internet.

It was decided not to produce brochures, but to rather focus on a good PowerPoint presentation and the Technology Transfer report. The website can be found at www.ufs.ac.za/salinity where copies of this final report and all the models will be available for downloading.

The following key results / lessons learned stemmed from this section of work:

a. The updated and modified economic models concluded that drainage is economically viable in many situations for salinity and water-logging management.

b. The financial models however concluded that, although economically viable, unless the farmer has no initial debt, that drainage is not financially feasible.

c. Furthermore, awarding a drainage grant would be necessary to incentivise most farmers to drain. In some cases a drainage grant alone was not sufficient, nor as effective as a policy instrument as subsidising the repayment interest rate of the loan.

d. In the worst case study the only way that the farmer could continue farming and remain financially feasible was if his current debt, together with re-establishment and drainage costs were consolidated and repaid at a subsidised interest rate.

It was reiterated at the meetings that the risks involved in awarding farmers a grant / bridging finance to install drainage, include:

a. Downstream externalities

b. Poor maintenance of the drainage leading to poor performance of the drains

c. Only planting low value crops and not generating higher value returns necessary to justify the drainage grant / support.

d. Crop price volatility in the long term planning that could overstate potential benefits.

The following noteworthy points were made:

a. The important role of WUA's for scheme level drainage management was realised and their need for support, training and personnel. In all the farmer and technician meetings it was mentioned that there is a desperate shortage of trained technicians to assist with drainage planning and monitoring of salinity and water-logging.

b. It was confirmed in the farmer and technician meetings that not just in the models, but on the ground also, drainage can dramatically increase the productivity of land.

c. Water-logging and salinity data collection, population of a database and an effective communications programme was agreed to be necessary at all the meetings.

d. Unfortunately the simplified farmer level methodology used and presented was turned down as it was agreed that most farmers wouldn't have the time to do it, although they were interested in having the information.

e. The developments of the Department of Soil Science current project in commercialising an EM38 ECe mapping device for an Oppermansgronde entrepreneur was mentioned and received with optimism.

f. Serious and concerted local action is required to further identify and raise the awareness of the salinisation and drainage threat; and political action and support is urgently needed to help curb further resource degradation through salinisation and drainage, and to regain the productivity of already salinised and water-logged areas. This can be achieved through *inter alia* drainage grants, debt consolidation and subsidised bridging finance mechanisms for existing debts and additional drainage financing costs.

g. An effective data measurement, analysis and communication programme together with local suitably trained technicians are also required as precursors for effective implementation and evaluation.

2.4 Aim 6: Final Report

The aim was to compile a user friendly technology transfer report of which this report is the result.

2.5 Guiding literature used in setting up the drainage financing models

Three main sources of literature were evaluated and interviews conducted to guide the process of setting up the drainage feasibility models; the World Bank literature (World Bank 2005 and 2006) was studied to evaluate the global trends, methods and significance of drainage. South African bank literature (Standard Bank, 2005) as well as Boehlje & Eidman (1984), Barry *et al.* (1988) and Wilson *et al.* (2006) was studied to get guidelines, and interviews were conducted with banking staff and tax experts to understand the process of drainage accounting, feasibility analysis and repayment ability evaluation. Existing local literature on drainage evaluation (Backeberg 1981, Le Roux *et al.* 1989, Van Rensburg *et al.* 2006 and Viljoen *et al*. 2006) was also studied and evaluated for application in this project.

2.5.1 A synopsis from the World Bank literature on their experience and needs assessment

Very importantly, recent World Bank literature (World Bank, 2005) recognises that in the arid zones of the world:

a. *"combating water-logging and salinisation of irrigated land remains a priority*

b. *without such investment, the growth of a more diversified and competitive type of farming may stagnate*

c. *drainage development can greatly enhance the well-being of the population and further environmentally appropriate land use."*

These premises make drainage investment for the World Bank (2005) "*a highly suitable instrument for broad-based rural development and integrated land and water resources management"*, very consistent with current political objectives in South Africa.

Drainage investment for the World Bank a highly suitable instrument for broad-based rural development and integrated land and water resources management

World Bank (2005) further states "*Water-logging and salinity are reducing water productivity over wide areas, yet investment in drainage is usually neglected in developing countries In Europe and North America, 30–40 percent of the agricultural land has land drainage systems, but in the developing countries this share drops to 5–10 percent. This difference is most plausibly explained by the fact that investment in drainage is not warranted when the productivity of the land is low. Farmers adapt to poor drainage by selecting tolerant but low-yielding or low-value crops and by applying minimal inputs. Many developing countries have, however, reached the stage in which lack of drainage is keeping ambitious farmers from achieving higher and more secure yields and from diversifying their crops. Where lack of drainage is a constraint, agricultural development risks stagnation and lacks competitiveness."* This seems to be very much the case in South Africa as well.

According to World Bank (2005) "*Most drainage projects have produced good rates of return and improved farmer incomes, yet investment has dwindled as projects have concentrated on upstream irrigation and farming. Investment costs are generally low, ranging from on-farm surface drainage systems at US$100 to $200 per hectare up to US$1,000 per hectare for pipe drainage in arid areas. Beyond individual economic benefit, drainage can contribute to overall land and water management and the environment. Drainage is a proven but demanding discipline and technology. Best investments are often highly case and site specific, and careful research and piloting are required. Integrated approaches address all on-site and off-site impacts of drainage. Although governments usually have to take the initiative, investment sustainability requires farmer involvement, as experience from pilots has shown. On-farm subsurface drainage systems are more costly with investments ranging from US$500 per hectare in the temperate zones to US$1,000 per hectare for salinity control of irrigated land in arid zones. The cost for the main systems would be US$250 to $500 per hectare. Operation and maintenance (O&M) costs may be estimated at 2–3 percent of the capital costs. Costs tend to drop as a drainage industry gains experience."*

Converting to Rands, at 2007 exchange rates this relates to R7 000 per hectare for pipe drains as the upper extreme/limit according to World Bank calculations. The question is, are South African conditions so different (impervious layers etc.) that our drainage costs are four times higher at R30 000/ha?

Even at R30 000/ha conserving existing land is cheaper than buying new irrigation land in the study area which traded for between R50 000 and R60 000 in 2007. This is also a motivating factor for World Bank

(2005) that states *"Drainage is also cost effective, because conserving already irrigated areas by (sub)-surface drainage costs only a third as much as building new irrigation systems".*

World Bank (2005) continues "*Drainage is a complex phenomenon with multiple impacts, positive and negative, on other functions of the resource system. Integrated resource management requires a new focus on drainage, which has to be analyzed within the context of a hydrological unit such as a basin, using an integrated approach and addressing all positive and negative impacts of drainage on and off site."* A new methodology ("DRAINFRAME," an acronym that stands for Drainage Integrated Analytical Framework) is described in (World Bank, 2005). It shows how a participatory planning methodology looking at every aspect of the resource system and all the stakeholders can untangle the multiple impacts, costs, and benefits; prioritize investments; and begin to locate benefits and mitigate side effects.

"Drainage is also cost effective, because conserving already irrigated areas by (sub)-surface drainage costs only a third as much as building new irrigation systems".

In concluding the summary of World Bank (2005), "*inevitably, some conflicts and downside risks are connected with drainage and use of low-quality water in irrigation. Environmental aspects need careful attention. Tradeoffs between different users may be essential, cost recovery is problematic, and technical innovations may be hard to accept culturally and difficult to manage, all of which underlines the need for good policy and planning and for integrated and participatory approaches*.

2.5.2 Bank determination of repayment ability

Traditionally, lenders apply the five C's of credit when determining the creditworthiness of agricultural borrowers (Wilson *et al.*, 2006):

a. The borrowers ***Capacity*** to repay the loan obligation and bear the associated financial risks, calculated by analysing both past and projected profitability and cash flow of the farm business. *If a farmer has previously installed drainage, increased return as a result of drainage records will be useful; otherwise data from a close neighbour with similar conditions who has installed drainage, or verified simulation models can also be used.*

b. The borrowers ***Capital*** available for farm operation, assessed from balance sheets with liquidity and solvency calculations to gauge equity invested in the farm and how effectively it generates cash flows. *Without sufficient capital (and managerial expertise) to optimise the returns from the investment in drainage (e.g. planting more capital intensive higher value long term crops), the investment may be underutilised.*

c. The borrowers' security ***Collateral*** as a final source of repayment if the borrower defaults on the terms of the loan agreement or dies. The higher the risk of the operation for which the loan is requested, the higher level of Collateral required. *As drainage has no salvage value, the full costs of the drains often needs to be covered by some form of collateral. The higher the percentage of a farmers' total land that needs to be drained, the less likely that the land itself can cover the collateral obligations.*

d. The ***Conditions*** for use of the funds, or the intended purpose of the funds required by the borrower are considered in terms of general economic conditions, interest rates, inflation and the demand for money in order to come up with a discount rate with which to calculate the net present value (NPV), benefit cost ratio (B/C) and internal rate of return (IRR), all useful in comparing funding alternatives.

e. The ***Character*** of the borrower, i.e. the attitude of the borrower towards risk and financial track record available form credit bureaus, is also a very important factor for commercial lenders considering a loan application. *In the case of subsidised state funding and grants the potential recipients character in terms of "money grabbing" and not applying the funds productively also needs to be evaluated to ensure efficient use of public funds.*

Symington (also an OR farmer) and De Villiers (2007), both from Standard bank were contacted on the banks' procedure and policy for determining a clients repayment ability when applying for a loan for drainage. A summary of the e-mail response from De Villiers (2007) follows:

a. Standard Bank is not prepared to provide details on their policy and the Excel model it uses for determining a farmers repayment ability
b. They can however help with a case study and advise to look in the Standard Bank book, Finance and the Farmer for more information on the Net Present Value principles
c. The following formula is how the bank determines repayment ability;
   Income Streams - Direct Costs – Overheads and/or Indirect Costs = Surplus before tax
d. Income can include non-farm income and income from assets sold, etc.
e. Overheads/Indirect Costs must include living expenses and/or the manager/owner remuneration/salary as well as non-farm expenses that are to be paid from the farming operations.
f. Depreciation must preferably be left out and a figure for capital replacement be deducted instead, where capital replacement is calculated at 10% per year of the amount required to replace loose assets today with a new replica of the asset. Actually the straight-line method should be used over the average serviceable life-time of the asset, but 10% is usually used as a quicker method.
g. Capital payments and/or interest on term debt should not be included in the overheads when the surpluses to be discounted are determined. Interest on overdrafts/production is to be included as they are considered part of production costs.
h. Net Present Value of the surpluses over 20 years = the amount of capital debt the farmer can repay (i.e. repayment ability)
i. It is preferred that a monthly cash flow is done for a 20 year period to include the seasonality which plays such a great role in agriculture, i.e. income coming in only at the end of the production season with costs occurring throughout the year. The Net Present Value must therefore be calculated for 240 months.
j. Standard Bank uses a long term discount rate to discount the surpluses (currently 16% per annum, accumulated monthly, i.e. 17.23% effective per annum).
k. The discount rate and the surpluses are both before tax and the effect of inflation is not included in prices and/or costs.

A financing model was compiled following *inter alia* these guidelines.

2.5.3 Benefit Cost Analysis

A decision-making tool used by Backeberg (1981), to evaluate capital investment on irrigation drainage is benefit cost analysis with the internal rate of return (IRR), the net present value (NPV) and the benefit cost ratio (BCR) as decision-making criteria. The NPV is the difference between the present value of income and present value of the capital and other expenditure. The B/C ratio is obtained by dividing the present value of the income by the present value of capital and other expenditure. The IRR is the breakeven discount rate at which the B/C ratio equals 1, or alternatively where the NPV equals zero.

The time period used in this study is 15 years and discount rates of 0%, 5%, 8% and 10% are used. 0% is used to indicate the potential farm returns as if the full cost of drainage was covered by the state as a sustainability grant, and farmers paid back the grant interest free. The South African Treasury has set a requirement that any projects requiring state funding achieve an IRR of greater than equal to 6% so as to remain viable and keep up with the planned economic growth rate of the country.

In Backeberg (1981) four soil classes requiring drainage were selected, each of which was further subdivided according to water-logging, salinisation and a combination of water-logging and salinisation, to determine the level of recovery from drainage over specified time intervals.

Costs of drainage in Backeberg (1981) were calculated for 1981 at between R1039 and R2711 per hectare based on information supplied by the same Reinders (2005) as referenced in the WRC study of which this report is a technology transfer action. Today 26 years later, Reinders (2005) calculates these costs to range between R15 000 and R30 000 per hectare.

Together with the cost of drainage, comes security from water-logging and salinisation enabling farmers to plant higher value crops. It may also be necessary for higher value crops to be planted to make the drainage costs feasible. These higher value crops are often long term crops requiring additional capital expenditure for establishment. Long-term, higher value crops also require a different irrigation system, adding to the long term stream of income and expenses.

Pannell and Schilizzi (2006) argues that *"discounting is a perennial problem for economists; it is an essential component of assessing economic comparisons over time, but a number of practical and theoretical difficulties continue to confront its use. This is especially so for economists concerned with long time horizons, such as the management of the environment and natural resources. Discounting is perhaps the area of economics that generates the most disquiet and confusion from outside the discipline."* For this reason the Conningarth Economists (2007) report provides a standardised set of norms for conducting a Benefit Cost Analysis.

Table 2.2 shows that changes in cash and capital flows between no drainage and with drainage using an On-Farm Leaching and Drainage Partial Budget framework. The framework calculates from annual changes in the cash flows the basic annual economic feasibility at Gross Margin (GM) level. Annual GMs combined with incremental capital flows produce the cash flow analysis where interest and bridging financing can be incorporated. Adding a discount rate instead of an interest rate to the cash flow, one can perform a Benefit Cost Analysis (BCA), to which one can add Equity Capital or Cash Surplus or a Grant to achieve a desirable IRR.

Table 2.2. The On-Farm Leaching and Drainage Partial Budget framework [1]

CAPITAL FLOWS			CASH FLOW		
WITHOUT DRAINAGE	***Δ***	***WITH DRAINAGE***	***WITHOUT DRAINAGE***	***Δ***	***WITH DRAINAGE***
Tractors	=	Tractors	Farm size	=	Farm size
Implements	=	Implements	Soil Types	=	Soil Types
Irrigation	=	Irrigation	Salinity levels	>	Salinity levels
Equipment	=	Equipment	Water Tables	>	Water Tables
Labour	=	Labour	Leaching fraction	<	Leaching fraction
Houses	=	Houses	Water to Drain	<	Water to Drain
NO Drainage	<	DRAINAGE	Crop Types	=	Crop Types
(External analysis of whole farm)		- Total Costs	Yields	<	Yields
		+ Bank Loan	Water Requirements/ ha	<	Water Requirements/ ha
		+ Gov. Grant	Crop rotation	=	Crop rotation
		- Own Equity	GM (rotation)	<	GM (rotation)
No maintenance	<	Maintaining	/ yr		/ yr

Incremental GM

Incremental Capital | Cash Flow

Discount Rate α Time

NPV, B/C ratio & IRR (Benefit Cost Analysis)
Equity Capital / Cash Surplus
Decision and Action

[1] **Personal Communication, G.Backeberg , 06/08/07**

2.5.4 Complete costing when including long term crops

Existing crops and irrigation systems may not be sufficient for feasible drainage installation. Higher value / permanent crops that require different irrigation systems may also have to be accounted for in the calculation of drainage costs feasibility. Table 2.3 lists the 2003 prices for various irrigation systems.

Table 2.3. New irrigation system costs (Personal Communication, Jacobsdal extension officers, 6/10/03)

Name	System	Cost (R/ha)			Comments:
FI	Flood	3 000	-	4 000	*R 5 000 – R 10 000 if laser levelled flood irrigation*
SI	Sprinkler	4 000	-	8 000	*Labour intensive*
CP	Centre Pivot	15 000	-	16 000	*Most common*
DM	Drip / micro	12 000	-	18 000	*Only suitable for grapes*
FI	Floppy	18 000	-	20 000	*Fastest growing new system (over head permanent sprinkler)*

Vineyards will generally be re-established after drainage. As it is very difficult to install drainage in an existing vineyard, the entire old vineyard has to be removed, soils worked to break up impervious layers, drains installed and the vineyards re-established. In this case, the main irrigation system remains intact, but the inline drippers/micro-jets have to be replaced. In the Vinpro & GWK budgets examined, vineyard establishment can range from R70 000 – R90 000 per hectare (2006 prices). Add to this drainage of up to R30 000 per hectare and vineyard establishment / re-establishment costs can go up to R 120 000 per ha.

2.6 Summary and conclusion

This section outlines the technology transfer procedure and feedback of this consultancy in the form of aims addressed, namely:

a. Aims 1 & 2: Presentation of Project results and buy-in for further analysis

b. Aims 3 & 4: Economic Models for annual crops in the Orange-Vaal and Orange-Riet WUA areas and an additional model for the Lower Orange River for perennial vine crops

c. Aim 5: The compilation of technology transfer material from the results of the models and presentation to key stakeholders for comment and review

d. Aim 6: Final Report

The chapter ends with a literature review that leads to the setting up of the drainage financing models used in this consultancy. Main statements were *inter alia*:

- Drainage investment is for the World Bank a highly suitable instrument for broad-based rural development and integrated land and water resources management (World Bank, 2005).
- Drainage is also cost effective, because conserving already irrigated areas by (sub)-surface drainage costs only a third as much as building new irrigation systems (World Bank, 2005)
- It is suggested to follow Conningarth Economists (2007) report when conducting a Benefit Cost Analysis as it provides a standardised procedure.
- Perennial crops such as vineyard establishment / re-establishment costs can go up to R 120 000 per ha (2006 prices) whereby drainage cost only make up one quarter (up to R30 000)

3. FARM LEVEL SALINITY AND DRAINAGE MANAGEMENT DECISIONS

This chapter is a basic overview of the main salinity and drainage mechanisms and management options that and their financial implications, identified as important for determining the financial feasibility of irrigation drainage. The chapter starts asking when a farmer needs drainage, and discusses salinisation and water-logging as the two main reasons. It goes on to describe where the salts come from that cause salinisation, salt distribution through the irrigation water, salinity cycles and trends and then discusses salinity measures and conversions used in calculating salinity economics. The impact of salinity on crops and the resulting economic and financial implications are then discussed. This is all applied to the case study farmers with a discussion on each, which leads to a methodology for financing drainage and concludes with suggested action.

3.1 When does a farmer need drainage?

The two main problems that may require artificial drainage are water-logging and salinisation where natural drainage is not sufficient. Where natural drainage is adequate, salinisation can still take place where sufficient leaching is not allowed to wash salts out of the plant root zone. Furthermore, initially adequately drained soils can also become water-logged without proper management; namely maintenance of soil structure by *inter alia* prevention of mechanical compaction and changing mineral compositions (correcting SAR & pH) and ensuring sufficient organic content in the soil. Maintaining soil in a good condition is a far more sustainable option than remediation / restoring of soils.

Where water-logging and salinisation do however occur urgent action needs to be taken to prevent further deterioration and this is a costly exercise, not only affecting the individual farmer, but his neighbours (externalities), community (job creation potential, direct spending and investment potential) and nation through depletion of a natural resource (the soil), unproductive water use and ultimately food insecurity.

3.1.1 Water-logging

Detection - Water-logging problems are often picked up from:

a. Clearly visible signs of water-logging including water layers and algal on the soil surface, plants dying off and falling over and machinery getting stucked.

b. Weekly irrigation scheduling reports (neutron moisture meters pick up saturated layers).

c. Yield grid reports and satellite images showing areas of reduced yield.

d. The type of clays in the soil is also an important factor determining soil permeability. These are identified by a detailed soil analysis and need to be managed very specifically.

e. The sulphur content of the soil and its propensity for water-logging.

Suggested action:

a. Go to affected area and first determine the presence of compacted layers using the penetrometer.

b. If not compacted, soil samples can be taken to determine infiltrability (i.e. sodium adsorption).

c. Mechanical / chemical remediation should first be tried before drains are recommended.

d. If this doesn’t work or is not recommended then consider drainage installation options.

3.1.2 Salinisation

Detection:

a. When visible as a salt crust on the surface of the soil, salinisation is already at a very advanced stage.

b. Salinisation can be picked up by reduced yield in certain areas where water-logging, compaction and other management factors are excluded.

c. Salinisation can cause a physiological drought in the soils, thus although soil moisture is sufficient / soils are filled to field capacity, crops still show signs of drought.

d. Salinisation is also directly correlated with the salinity of the irrigation water used as irrigated soils build up salts deposited through the irrigation water or maintain an equilibrium with the irrigation water where sufficient drainage takes place.

e. Water-logging / saline groundwater intrusion is often a precursor to salinisation.

f. Salt mineralization of the soil (test soil saturated ECe).

Suggested actions:

a. Chemical remediation (the correct combinations of lime, gypsum / dolomite – get advice from the fertilizer company – the composition of the fertilizer also needs to be taken into consideration).

b. Bio-logical remediation (increase soil carbon with organic matter).

c. Drainage: the following team-work process is suggested to conduct a technical, economic and financial feasibility analysis.

   1. Consult a drainage engineer (DoA, DWAF, WUA or private sector) to determine the extent and basic costs of the drainage required (as well as government programmes and support options):

      · *Surface drainage vs. underground drainage.*

      · *Cut-off vs. partial area vs. full area drainage.*

      · *Return flow management options (important to consult with your local WUA).*

   2. Consult and agricultural economist / accountant to determine the **economic viability** of the proposed drainage (i.e. the ability of the increased returns from drainage to cover additional costs to drain, determined by applying the Benefit Costs Analysis technique).

If not viable (NPV<0, B/C<1, IRR < bank discount rate), investigate the viability of:

- *planting a higher value crop (usually more capital intensive and greater risk),*
- *abandoning drainage and planting a more salt tolerant crop (usually lower value),*
- *retiring the land and developing new land,*
- *apply for a grant (only if IRR > treasury threshold of 6%).*

If viable (NPV>0, B/C>1, IRR > bank discount rate), draw up a business plan to apply for a loan, taking heed of the following:

- *conduct a sensitivity analysis.*

3. Consult with bank manager to determine the **financial feasibility.**

   · *If not feasible (cash flow problem) negotiate interest rate / apply for grant.*

3.2 Where do salts come from?

There are five main sources of salts that cause salinisation:

a. Salts dissolved in the irrigation water that get added to the soils and can't drain, thus building up in the soils.

b. Mineralization of salts in the soil / rocks in the soil accelerated by the wet conditions caused by irrigation.

c. Groundwater intrusion and water-logging through capillary movement or migration in saturated conditions, mineralised salts or salts in the groundwater migrate to the soil surface where they accumulate. Over utilization of coastal aquifers can result in sea water intrusion into the groundwater of the coastal aquifer.

d. Wind and flood deposited salts from either sea water or from neighbouring salt pans or dry surfaces where salts have accumulated on the surface over the past.

e. Salts added to the soils through chemical amendments and fertilizers.

3.2.1 Salinisation Measures and Conversions

Irrigation water salinity is measured as TDS (total dissolved solids) or EC (electrical conductivity).

a. TDS is sometimes referred to as the total salinity and is measured or expressed in parts per million (ppm) or in the equivalent units of milligrams per litre or mg/l (1mg/l = 1ppm). TDS(lb/ac-ft) = TDS(mg/l) X 2.72.

b. EC is a measure of electrical current and is reported in mmhos/cm, µmhos/cm mS/m or dS/m (100mS/m = 1dS/m = 1mmhos/cm = 1000µmhos/cm).

   Subscripts are used with the symbol EC to identify the source of the sample:

   - EC_{iw} is the electrical conductivity of the irrigation water.
   - EC_e is the electrical conductivity of the soil as measured in a soil sample (saturated extract) taken from the root zone.
   - EC_d is used to determine the salinity of the drainage water that leaches below the root zone.

Various TDS to EC (and *vice versa*) conversions are published in the water quality literature, but these are usually very vague and / or site specific.

EC is an indirect measure of the concentration of the total dissolved solids in solution – the greater the concentration of salts in solution the greater the ability to conduct an electrical current. EC (mS/m) is measured more easily than TDS (mg/l or ppm) and thus used more widely in databases storing water quality data. EC is related to TDS by multiplying EC by a factor of between 6 and 7 depending on the composition of dissolved salts (DWAF, 1993:31-35). In the study by Marshall & Jones (1997) the TDS to EC conversion used was 650mg/l = 1mmohs/cm where 1dS/m = 1mmhos/cm.

Meyer *et al.* (1994) use 640 as the conversion from dS/m to mg/l or 6.4 from mS/m to mg/l. This can be seen in Figure 3.1; On the left, the Swagman Saltimeter (Meyer *et al.* 2004) developed jointly and used by both the USDA's ARS and Australia's CSIRO as a technology transfer tool to compare various units of salinity,

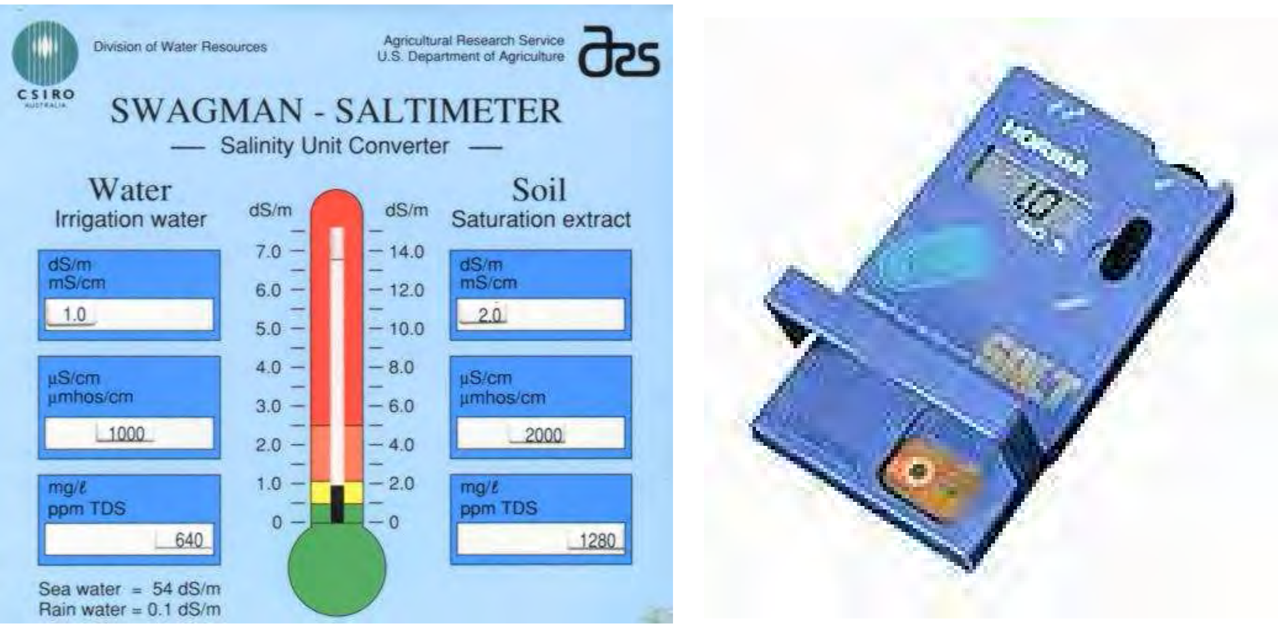


Figure 3.1. *Left:* The Swagman Saltimeter (Meyer *et al.* 2004) *Right:* The Cardy Salt meter by Horiba

convert irrigation water to soil water salinity and to classify soil salinity according to suitability for crop production, and on the right, the Cardy Salt meter by Horiba, only requiring one drop of either irrigation water or saturated soil solution to give an accurate field measure of the salinity.

Table 3.1 is a description of the working ranges of the Swagman Saltimeter in Figure 3.1, explaining broadly the salinity - crop yield relations dependent on the salinity tolerance status of various crops.

Table 3.1. Salinity effect on crops according to Swagman Saltimeter (Meyer *et al.* 1994)

TDSiw = ECiw x 640 *ECe = ECiw x 2*					*Irrigation water*		*Soil Saturation Extract*	
					ECiw	TDSiw	ECe	TDSe
					dS/m	mg/l	dS/m	mg/l
Zone	Class	Effect	Range		mS/cm	ppm	mS/cm	ppm
Green Zone	Low Salinity	No effect on crops	0	-	0.5	320	1	640
Yellow Zone	Modulate Salinity	Very salt sensitive crops will be affected	0.5	-	1	640	2	1280
Pink Zone	Highly Saline	Salt tollerant crops only should be grown. Rapid soil salinisation may occur	1	-	2.5	1600	5	3200
Red Zone	Very Highly Saline	Unsuitable for irrigation if water salt levels are >5 dS/m. Soil salinities >10 dS/m are unlikely to sustain any useful crops	2.5	-	5	3200	10	6400
Sea Water			54					

A once off reading as made with the Cardy Salt Meter in Figure 3.1 and converted with the Swagman Saltimeter is static (for one very specific point in place and time), but the true value of the reading is knowing the direction of soil salinisation (i.e. building up or improving due to leaching) by plotting this reading with previous readings taken at the same sample site. We therefore also need to understand how salts are distributed in the irrigation water, what salinity cycles and trends occur and how to measuring salts in the soil before the link to crop yield can be made.

3.2.2 Salt distribution in the irrigation water (downstream concentration and dilution effects)

The factors affecting salinity in a river (i.e. its hydrology) are *inter alia*:

a. the level of water use and concentrated return flows allowed back into the river through either point-source or non-point source drainage,

b. the rainfall and natural salt wash-off and leaching throughout the river catchment that feeds the river and its tributaries,

c. the effect of dams and weirs on evaporative concentration, and

d. saline groundwater intrusion.

Hence there are more factors affecting the salinity of downstream users than merely drainage and other upstream pollution externalities.

The rates of salinisation of the soil as one moves down a river depend on, besides the water quality that the irrigator receives, the evapo-transpiration in the area and hence the derived water allocation volume a farmer uses per hectare. To illustrate the salinisation potential as a factor of quota and concentration, Table 3.2 shows how at different points along the Orange River change in their potential for salt mass accumulation.

Table 3.2. Salt Mass accumulation potential of soils as a factor of Quota and Concentration

Region	*Quota*	*[salt]*	*Mass*
Unit	m3/ha/yr	mg/l	ton/ha/yr
Orange Riet	9 000	250	2 250
Lower Riet	9 000	750	6 750
Orange Vaal	11 000	600	6 600
Boegoeberg	15 000	250	3 750
Kakamas	18 000	350	6 300

The Orange Riet scheme area of the OR-WUA receives pure Orange River water with a salt concentration of 250 mg/l and being in a higher rainfall area of the Orange River catchment receives an water quota of 9000 m^3/ha/yr, equating to a potential salt load mass of 2250 ton/ha/yr. As one moves downstream in the Orange River into lower rainfall areas, the quota increases, average irrigation water salt concentration vary due to the influence of tributaries etc. and at Kakamas, although the salt concentration of the irrigation water is relatively good and according to the Swagman Saltimeter (Meyer, 1994) should generally have no effect on crops, due to the high volumes of water required to irrigate, a large mass of salts have the potential to accumulate in the soils, rendering soils salinised and hence affecting crop yields.

3.2.3 Salinity cycles and trends

> ***It is impossible to step twice into the same river. You step into a river; your step out; your step in again; but you do not step into the same river, for the water has flowed on and it is a different river. Everything is in a constantly changing state of flux.***
> *Heraclitus, 560BC*

As river water salinity (especially in the study area) is constantly changing, soils are seldom in a state of equilibrium where soil salinity is constant.

The seasonality of the irrigation water salinity fluctuations can be clearly seen in Figure 3.2 for the Lower Riet River where TDS and EC are plotted for ten years from 1990 till 2000.

The peaks in irrigation water salinity in Figure 3.2 for each year occur between August and December. The drastic improvement in water quality that occurs from after the peak till April is usually as a result of the onset of the rainfall season in the study area and the catchments in the upper river reaches. A less dramatic increase again occurs from April to August as river flow decreases and excess irrigation water that had been applied to irrigate crops seeps through the soil and returns into the river laden with salts.

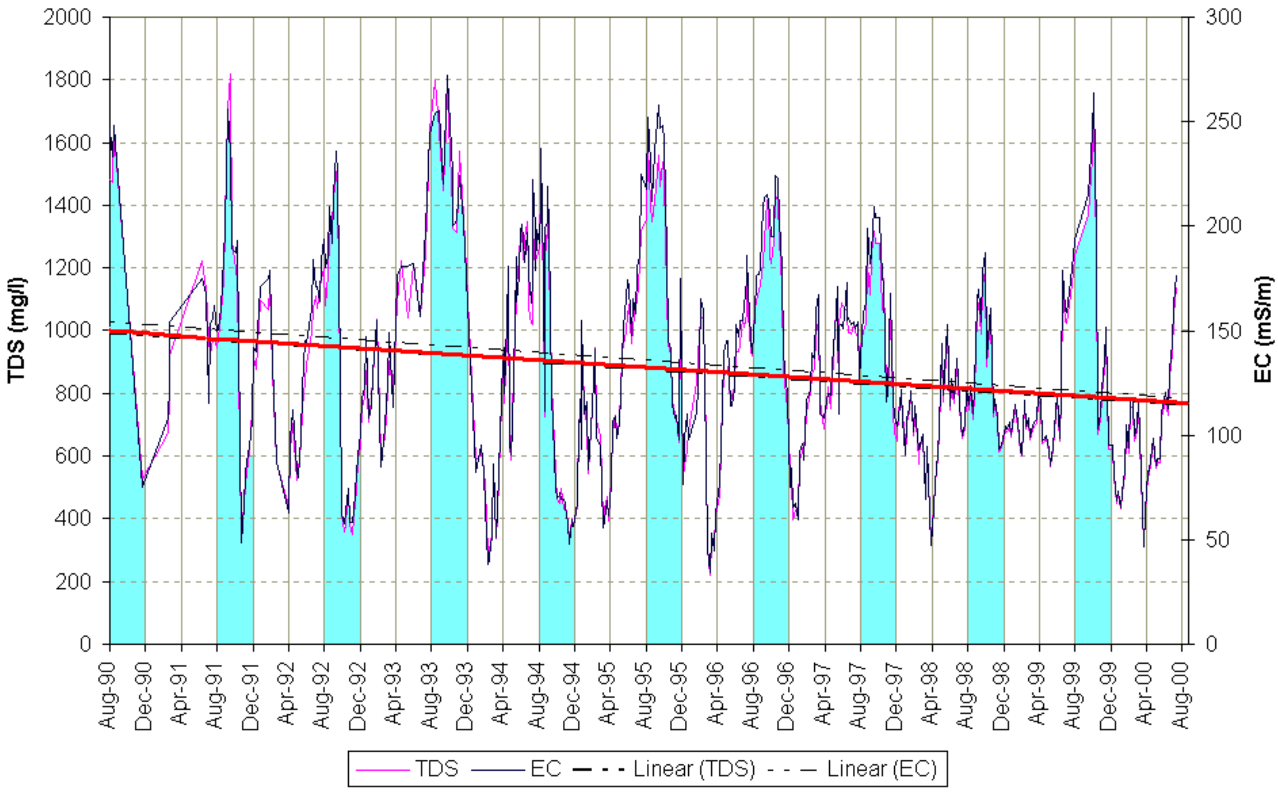


Figure 3.2 Irrigation water salinity fluctuations measured as EC(mS/m) and TDS(mg/l) at Soutpansdrift on the Riet River, DWAF 1990-2000

Also notable in Figure 3.2 is the trend in average salinity over the ten years. This could be due to improved irrigation efficiencies brought about by the price-cost squeeze and improved irrigation management resulting in less leaching, or it could be as a result of more Orange River water being transferred into the system and having a dilution effect. It could also be that the ten years of analysis starts with the end of a long term dry cycle, entering and progressing through a long term wetter cycle and ending on the turning point of another dry cycle.

Figure 3.3 is a 20-year simulation of soil saliniy (TDSe) in the Lower Riet area of the OR-WUA with and without drainage using the DWAF Water Resources Planning Model (WRPM). Superimposed over the graph are the Swagman Saltimeter colour coded ranges for crop tollerance as shown in Figure 3.1 and explained in Table 3.1. Without drainage clear long term trends of increasing salinity can be see (month 12 to 70, 75 to 160 and 170 to 240) , broken by 1 in 10 yeear floods of very wet seasons (around months 70 and 165). The inter year (seasonal) fluctation are also clearly visible.

Without drainage salinity predominantly fluctuates within the Highly Saline zone and occasionally enters the Very Highly Saline zone. After the first season with drainage installed, soil salinity drops out of the Highly Saline zone and after a further three to six years remains predominantly in the Low Salinity zone, safe for irrigation of all crops. This clearly illustrates the effectivity of drainage in keeping soil salinity under control.

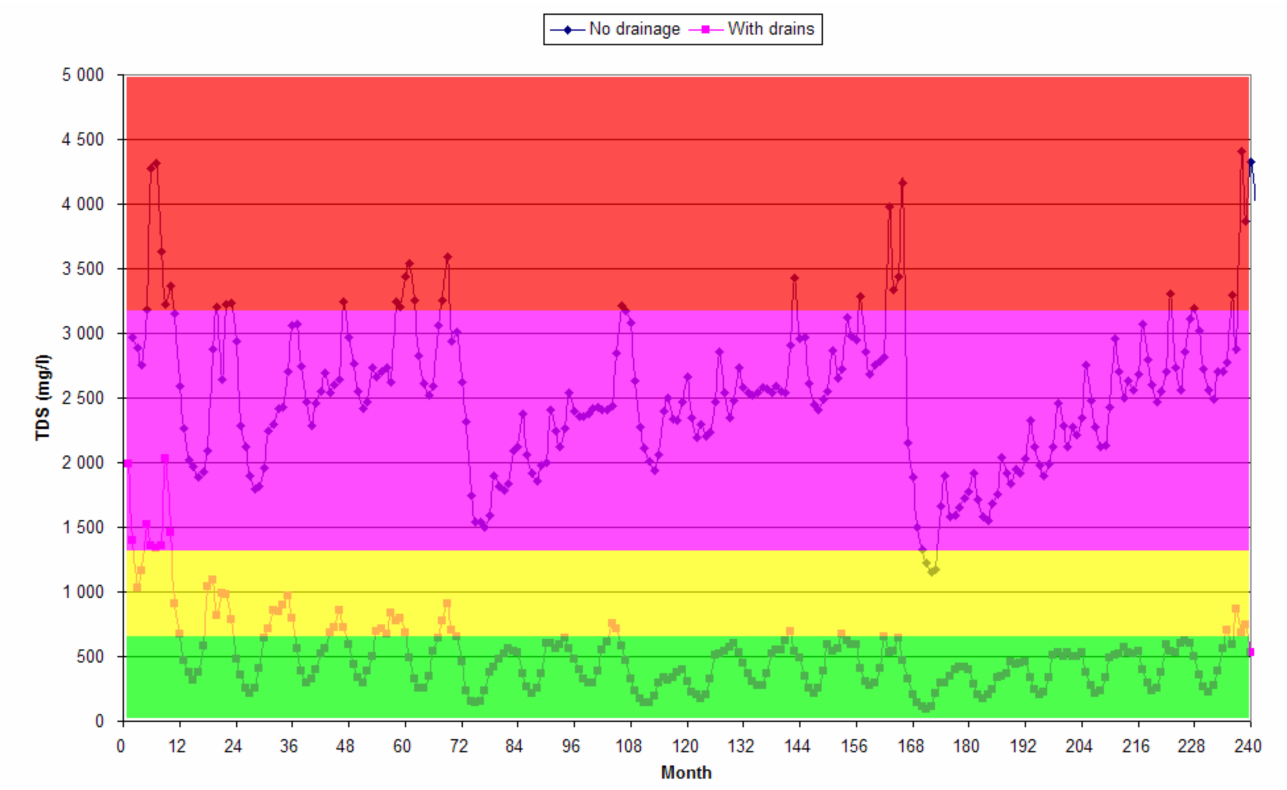


Figure 3.3. A 20-year simulation of TDSe in the Lower Riet with and without drainage (WRPM Stochastic run 44) with the Swagman Saltimeter ranges superimposed

3.2.4 Measuring salinisation of the soil

Just as salinity changes can fluctuates at different points in space and time in the river, there is also enormous spatial variability within the soil (depth) and across its surface as illustrated in Figure 3.3.

The discussion that follows on Figure 3.4 is hypothetical, aimed at illustrating the enormous in-field variability in soil salinisation and possible remediation actions. Similar pictures can be obtained free of charge from Google earth on http://earth.google.com.

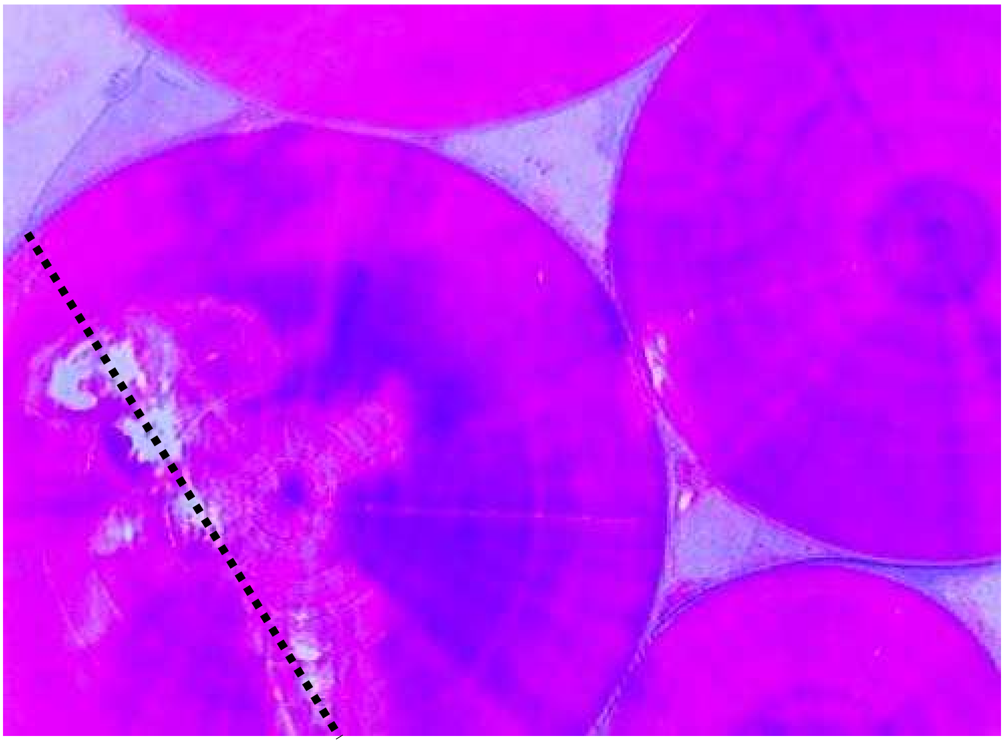


Figure 3.4. An inverted colour spectral imagery view (aerial photo) of a salt affected centre pivot land (courtesy GWK, 2002)

Figure 3.4 is an aerial view of an irrigation field under centre pivot in the study area affected by salinisation. The white areas clearly show salinisation and the darkest areas show good crop growth. The areas in-between are where crop growth occurs, but where the effect of salinisation is not yet clearly visible to the naked eye. If the field is 40 hectares, then roughly 10 hectares has near optimal crop growth, 5 hectares no growth and the rest in-between. The purpose of this illustration is to show that salinity is not clearly delineated in a field, and due to in-field variability in soil salinity choosing one point of measurement may be misleading. Grid sampling or salinity mapping therefore needs to be applied.

In Figure 3.4, the installation of one straight sub surface drain, depending on the slope of the field along the dashed line drawn in the diagram, may suffice to sufficiently leach out the salts accumulated. The dashed line may also represent a dip in the field where salts have accumulated, causing water-logging problems which exacerbate the impacts of salinity, though salinity doesn't have as great an effect on crop yields under wet conditions than under dry conditions. The dashed line may also represent a peak in the field where salts have migrated to along the moisture gradient of the field, or may represent an underground soil bank that has a significantly different texture from the rest of the field.

The discussion on Figure 3.4 highlights the need of field specific solutions for salinisation problems, such as salinity mapping and/or precision farming solutions. With minimal expense a farmer can acquire the basic apparatus in Figure 3.5 to calculate your own in field soil salinity values.

Mr Mvuli, a Bucklands Farmer near Douglas eagerly helping, learning and waiting to see the salinity status of the soil on his newly acquired land.

Miss Keneilwe Nailana was the research assistant preparing the samples assisting with the WRC project.

Photos by R.J.Armour

Figure 3.5. A possible infield ECe self-testing kit comprising of a soil bore, vacuum pump and filter (left) and on the right a close up of the salinity meter and probe inserted in the vacuum cup and the ceramic funnel and filter paper containing the saturated soil paste.

Figure 3.5 is a possible infield ECe self-testing kit comprising of a soil bore, vacuum pump and filter on the left, and on the right a close up of the salinity meter and probe (Hanna Instruments) inserted into the vacuum cup and the ceramic funnel and filter paper containing the saturated soil paste

A hypothetical example of salt build-up potential in the soil in the absence of drainage and wash-off and leaching is given in **Table 3.3**. At a volumetric quota of 1 100 mm per hectare per year at a concentration of 100 mg per litre, relates to a mass of 11 tons of salt being added to the one hectare each year. In the first year a two (2) meter depth of soil will contain a mass of 20 tons of salt

Table 3.3. Bio-physical (land-water-salt interaction) salt concentration to mass illustration C:\...\Basic demo model - FARMERS.xls

Irrigation water salt load		
Plot	1	ha
Water quota	1 100	mm/ha/yr
=	11 000	m^3 / yr
=	11 000 000	Litres
Irrigation water TDS	1 000	mg/l
salts added	11 000 000 000	mg / year
=	11 000	kg / yr
=	11.00	ton/year

Soil salt mass accumulation		
Soil water salinity TDS (irrig.TDS x 2)	2 000	mg/l
Soil water salinity EC (Soil TDS / 6.5)	308	mS/m
Soil water depth	2	m
Soil water capacity	50	%
Saturated soil water volume	10 000	m^3
=	10 000 000	litres
Soil salt mass	20 000 000 000	mg
=	20 000	kg in yr1
=	20.00	ton in yr1

3.3 Impact on crops: Relating soil salinisation to yield reduction

The first three (3) columns of Table 3.4 are the data required for the 20 most important crops in the study area. The fourth column is used to calculate the additional water required with the corresponding leaching rate, and to calculate the water and pump costs thereof. The last two columns, using the conversion factors by Meyer *et al.* (2004) relate soil saturated paste (ECe) back to irrigation water values in mS/m (ECiw) and mg/l (TDSiw).

Table 3.4. Crop specific data requirements for populating the models

	ECe Threshold	*ECe Gradient*	*Max. Yield*	*Crop Water requirements*	*ECiw Irrigation Water Threshold*	*TDSiw Irrigation Water Threshold*
	mS/m	%/mS/m	Ton/ha	mm/ha	mS/m	mg/l
Barley	800	0.07	6.0	820	400	2 560
Beets	400	0.09	35.0	535	200	1 280
Carrots	100	0.14	50.0	514	50	320
Cotton	770	0.05	5.0	1027	385	2 464
Cucurbits	250	0.13	50.0	695	125	800
Dry_Beans	160	0.10	3.5	447	80	512
Fruit	170	0.21	21.0	1620	85	544
Lucerne	200	0.07	20.4	1576	100	640
Maize	170	0.12	14.0	1022	85	544
Olives	300	0.19	6.4	746	150	960
Onions	120	0.16	55.0	329	60	384
Pastures	600	0.07	8.0	1127	300	1 920
Peanuts	320	0.29	4.0	807	160	1 024
Pecan_nuts	150	0.19	1.6	854	75	480
Potatoes	170	0.12	45.0	743	85	544
Soybeans	500	0.20	6.0	863	250	1 600
Sunflower	500	0.09	4.0	560	250	1 600
Vegetables	700	0.09	40.0	824	350	2 240
Vineyards	150	0.10	30.0	1443	75	480
Wheat	600	0.07	7.0	820	300	1 920

The first three (3) columns of Table 3.4 are inputted into the Maas and Hoffmann equation as shown in **Figure 3.6** to determine the corresponding percentage loss in yield due of soil salinity.

Working of the Maas & Hoffman (1977) equation							
Weighted ave. ECe (mS/m)	*330*	*= TDSiw*	*1056*		*mg/l*	*(x 6.4 /2)*	
	Units	LUCERN	MAIZE	VINES	WHEAT	Onions	< Choose crop to view on graph
ECe Threshold	mS/m	200	170	150	600	120	
ECe Gradient	%/mS/m	0.073	0.120	0.096	0.071	0.160	
Max Physiological yield	ton/ha	20.40	14.00	30.00	7.00	55.00	
% of max Physiological yield	%	91	81	83	100	66	
Expected yield	**ton/ha**	**18.46**	**11.31**	**24.82**	**7.00**	**36.52**	
Yield loss	**ton/ha**	**1.94**	**2.69**	**5.18**	**0.00**	**18.48**	
Crop price	**R/ton**	R 600	R 1 500	R 1 000	R 2 000	R 23 532	
Financial loss	**R/ha**	R -1 162	R -4 032	R -5 184	R 0	R -434 877	

The Maas & Hoffman Equation

IF ECe < Threshold THEN

Y=100% of max yield

ELSE

Y=100-((Threshold-ECe)*Gradient))

	% max Yield			
ECe	LUCERN	MAIZE	VINES	WHEAT
0	100	100	100	100
50	100	100	100	100
100	100	100	100	100
150	100	100	100	100
200	100	96	95	100
250	96	90	90	100
300	93	84	86	100
350	89	78	81	100
400	85	72	76	100
450	82	66	71	100
500	78	60	66	100
550	74	54	62	100
600	71	48	57	100
650	67	42	52	96

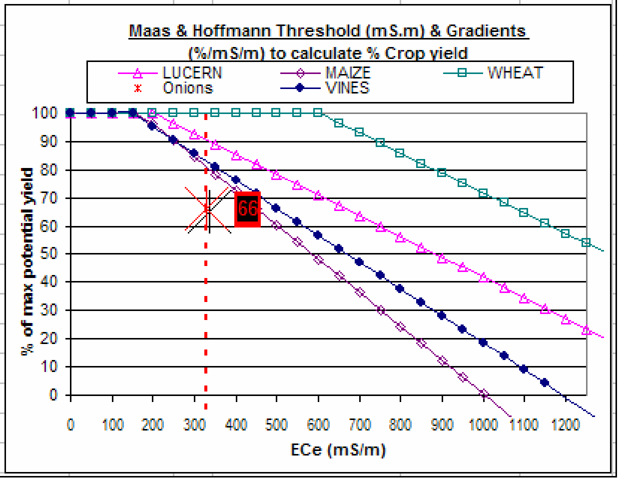


Figure 3.6. A demonstration of the Maas & Hoffman (1977) equation for converting Soil salinity (ECe) to yield loss (ton/ha) to financial loss (R/ha)

Figure 3.6 goes a step further than calculating the expected yield; it puts a financial value to the lost production by multiplying the yield loss by the expected crop price. If this potential increase in value exceeds the annualised costs of drainage, then this is a first indication that drainage is feasible.

3.4 Economic implications

The economic viability of drainage refers to the per hectare ability of the direct increase in profitability as a result of drainage to repay the capital required to drain, whereas financial feasibility refers to the ability of the farming unit to access sufficient additional funds to pay for the drainage required and maintain an overall increasing cash flow in the long term or positive Net Present Value (NPV). Economic viability is a prerequisite for financial feasibility. This section looks at only the economic viability.

A table showing a basic guideline for the calculation of drainage costs is shown in Table 4.1 in the Service Provider section chapter of this document as it is recommended that the farmer seek professional advice from an irrigation scientists (soil scientist / irrigation engineer) to calculate the right depths and spacing of drainage pipes for the specific field that needs to be drained.

Once the farmer has an indication of what his drainage costs will be, Table 3.5 is an example of how to determine direct economic viability of drainage for a specific crop on a Gross Margin (GM) level.

The first step is to determine the current Crop Gross Margin (Current Yield x Price minus direct input costs). Next determine what the maximum potential yield for the crop should be with sufficient drainage and subtract the input costs together with the additional direct cost of drainage (increase water and electricity use due to leaching) to get the maximum GM with drainage, factoring in only the direct costs of drainage.

Knowing what the potential drainage will costs, calculate the annual repayments of the drainage installation and annual maintenance costs and subtract this from the maximum GM with drainage (direct costs only) to get the Max GM with drainage (direct, finance and maintenance cost included).

Table 3.5. Crop Gross Margin (GM) with and without drainage

Crop	MAIZE	
Threshold	170	mS/m
Gradient	0.12	%/mS/ha
Max Yield	12	Ton
Current Yield (water-logging + salinity)	10	Ton
Price	1 800	R/ton
Input costs (no leaching)	9 000	R/ha
Max GM with no drains	9 000	R/ha
Water & electricity cost	1	R/mm
Crop water requirement	800	mm/ha
Water & Electricity cost	800	R/ha
Leaching	10	%
Returnflow salinity	13 750	mg/l
	2 115	mS/m
Crop water requirement+	880	mm/ha
Water & Electricity cost+	880	
Change in Water & Electricity cost+	80	R/ha
Input costs (with leaching & drainage)	9 155	
Max GM with drainage (direct costs only)	12 445	R/ha
Drainage costs	15 000	R/ha
Term	15	Years
Interest Rate	16.0	%
Repayment	-2 690	R/yr
Drainage Maintenance	0.5	% if cost
Drainage Maintenance cost	75	R/ha
Max GM with drainage (direct, finance and maintenance cost included)	9 680	R/ha

3.5 Financial impacts

Figure 3.7 is a series of graphs showing the build-up of salts in the soil (top left), the impact on yields and this translated to the financial impacts, i.e. the impact on cash flow with interest calculated in the incomes and expenses streams. The graphs on the right clearly show that without drainage the cumulative gross margin cash flow declines into the negative (negative slope) while with drainage it increases (positive slope). In this example it is financially feasible to repay the full cost of the loan for drainage.

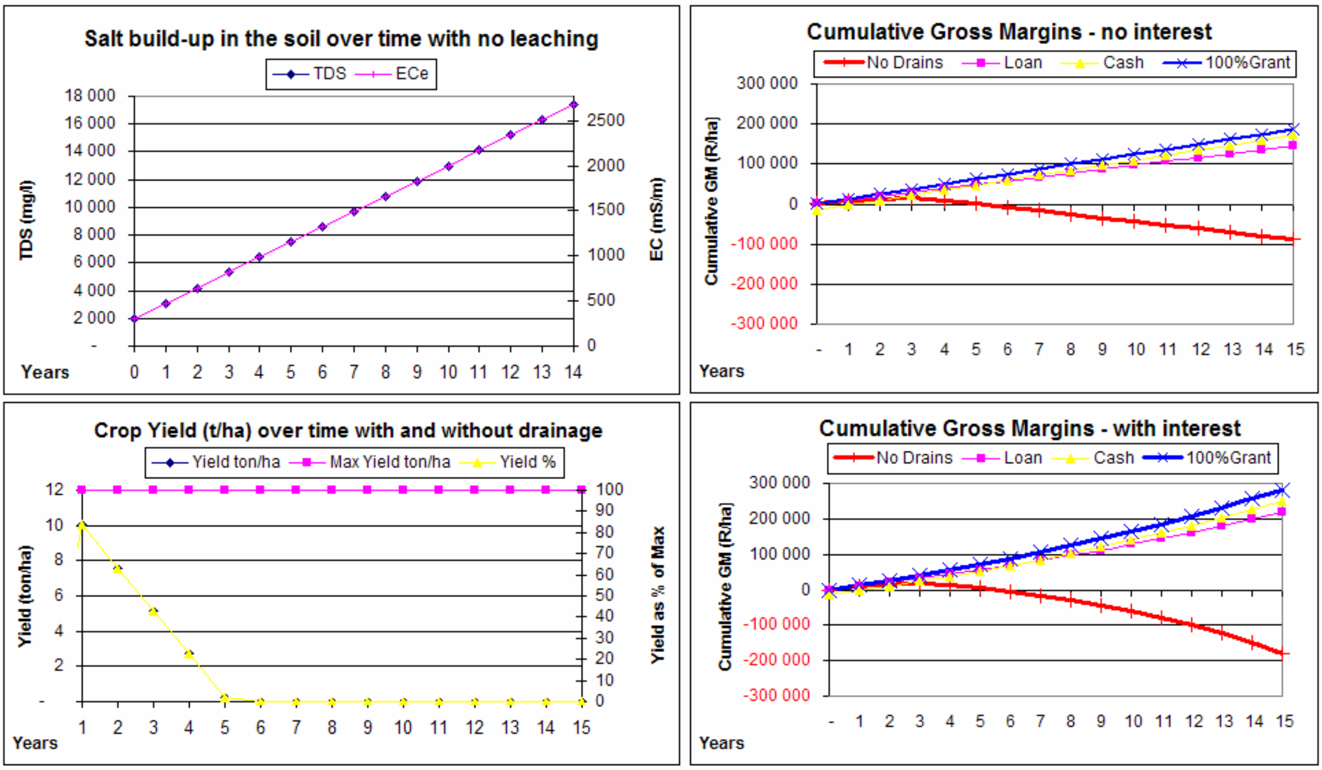


Figure 3.7 Basic results from the expanded salt mass illustration model

3.6 Case study farms (CSFs) used in this study

For a detailed description of the case study farms see Appendix 3. which includes the procedure followed for selecting the specific case study farms.

Two case study farms were selected for the OR-WUA, namely a commercial farm with no debt (ORc) and a land reform farm where new beneficiaries have been established (ORn). One commercial farm was selected for the OV-WUA and one for the LO-WUA. The LO case study farm was modelled with actual OR irrigation water salinity as well as with Lower Riet irrigation water salinity.

The very basic principles explained thus far of salt accumulation in the soil and the effects on plants are applied to each of 4 case study farmers.

Figure 3.8 lists the differences in saturated soil salt concentration over the four case study farms as simulated using DWAF's WRPModel (Stochastic run 1 of 100). The Orange-Vaal case study farm (OV) starts with a high ECe for the first 6 years after which it suddenly falls (high rainfall event or a 1 in 10 year flood?). There is then another steady climb for the next 6 years again, only to flatten out for three years and drop again. Both the Orange-Riet WUA farmer (OR) and new / emerging Orange-Riet WUA (RN) case study farmers receive good quality water from the Orange River. However the LO case study farmer much further downstream experiences much higher irrigation salinity, but also has water-logging problems; so the salts don't wash out.

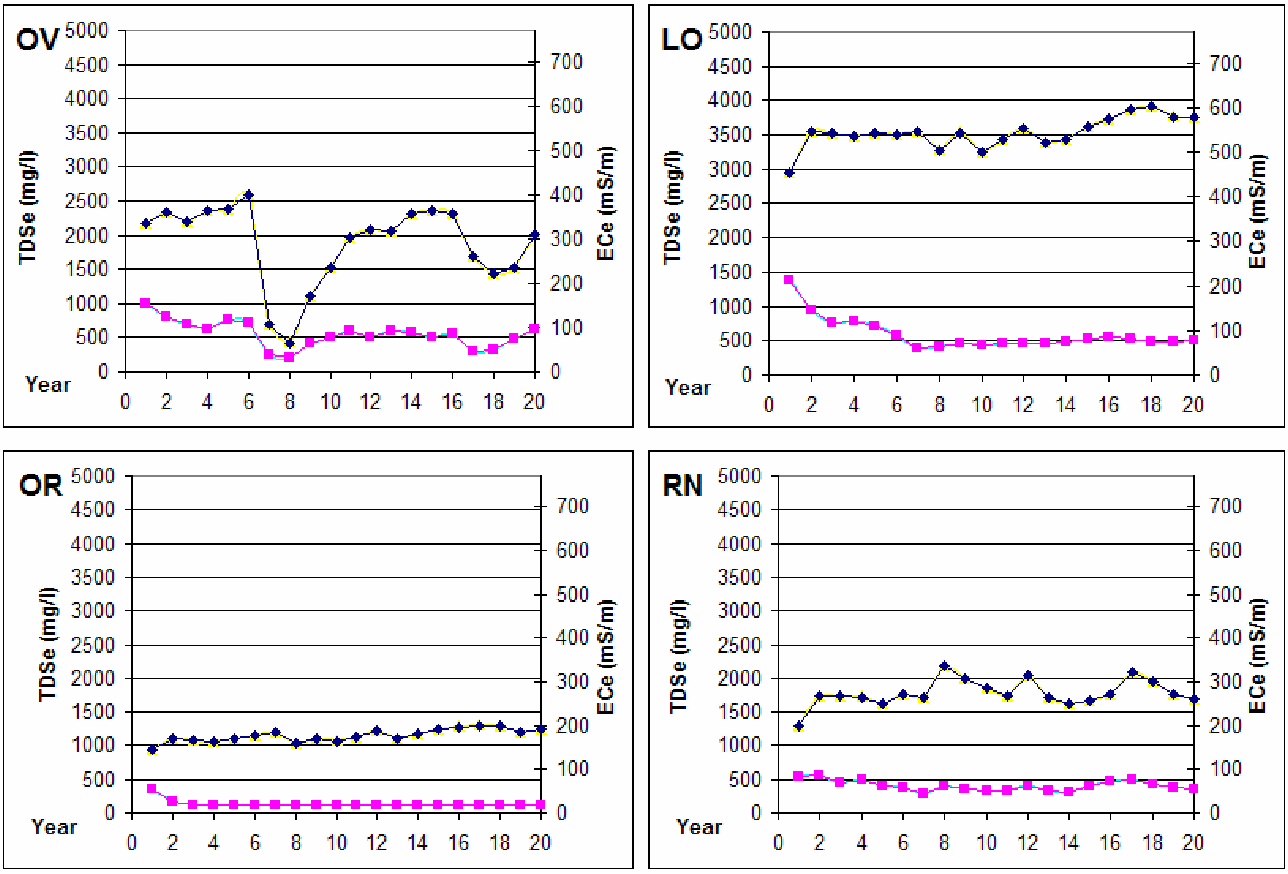


Figure 3.8. A comparison of the saturated soil TDS (mg/l) with artificial drainage installed (bottom line) and without sufficient drainage (top line) for the four case study farms

3.7 Financing drainage

The farmer has a few options regarding funding for the installation of drains:

- finance the drainage himself,
- apply for a drainage grant if the state is making these available,
- organize bridging finance with a bank,
- arrange for the consolidation of all debt and negotiate a subsidised interest rate.

Even thought drainage proves to be economically viable for a specific scenario it may not necessarily be financially viable to install without various subsidies and grants.

Figure 3.9 is an example of the first page of a farm level model where the rates and level of debt can be changed to see the impact on the financial feasibility of drainage.

Calculationof bridging finance repayment costs after years

Water fees	R/mm	0.35		Water quality scenario: 1
Electricity fees	R/unit	0.68		
Current debt (total)	R	0	-3 340 000 linked	
Diesel price	R/unit	6.50		

Drainage loan calculation

Area requiring drainage	ha	40.0	
Drainge loan interest rate	%/anum	8.00%	
Drainage repayment term	years	20	
Drainage maintenance cost	% total	1%	
Total drainage costs per ha	R/ha	R 28 571	
Own capital available for drainage	R/ha	R 0	
GRANT for drainage	%	50%	571 429
Total to loan for drainage		571 429	-58 201 per yr repayment

Bank Bal. interest rate

Running balance per yr	
-ve (<0)	13.50%
+ve (>0)	3.50%

Crop data:

		Maize	Cotton	Lucerne	Vineyards	Wheat
Crop salinity threshold	mS/m	170	770	200	150	600
Crop salinity gradient	% / mS/m	0.12	0.052	0.073	0.096	0.071
Water logging factor (WLF)	% y reduction	5%	20%	50%	30%	20%
Leaching Fraction	nore than requ	*10%*	*0%*	*5%*	*10%*	*0%*
Crop prices *(real 10yr ave.)*	R/ton	832	3 016	552	725	1 208
Max Yield *(expert opinion)*	t/ha	14.0	5.0	20.4	20.4	7.0
		5%	20%	8%	30%	20%

Best performing crops:

	Pre Drains	Post Drain	NPV %Δ	NPV RΔ
5% NPV	Wht-Mz	Lucerne	Lucerne	Lucerne
8% NPV	Wht-Mz	Lucerne	Lucerne	Lucerne
12% NPV	Wht-Mz	Wht-Mz	Lucerne	Lucerne

Farm analysis results

Cropping composition	Wheat-Maize ratio	Current ha	New ha	Max new	
Maize	75%	0.0	0.0	ok	328.7
Cotton		0.0	0.0	ok	328.7
Lucerne		40.0	40.0	ok	243.4
Vines		0.0	0.0	ok	49.8
Wheat	100%	0.0	0.0	ok	0.0
	Sum:	*40.0*	*40.0*	***ok***	0.0

	NPV 5%	NPV 8%	NPV 12%	IRR
Current situation	186 901	99 881	23 181	
Additional drainage	2 226 377	1 590 343	1 025 359	31.0%
Additional drainage & bridging finance	1 745 692	1 211 643	737 252	25.9%
Incremental between current & new scenario	**2 039 476**	**1 490 462**	**1 002 177**	**37.3%**

Cash Flow:

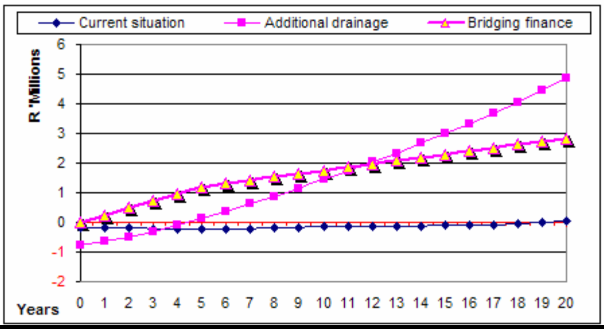


Figure 3.9. A farm-level analysis scenario model example (OV case study farm)

Figure 3.10 presents the basic information on which Figure 3.9 is built, showing the calculation of the bridging finance and the calculation of the total collateral value of the farm to constrain the selection of a different unrealistic cropping combination. The calculations used in determining the bridging finance is also listed. Also shown are NPV and IRR of the 5 main crops grown in the study area, calculated at various discount rates.

Bridging finance calculations:

Repayment after x years	years	5
Repayment interest rate		8.00%
Repayment term	years	15
Bridging finance required	R	771 429
Interest		377 881
Payment		**-131 801**

Calculation of the colateral value of the fixed capital component of the farm

	R/ha	ha	TOTAL
Farm size (irrigable water rights)		141	
Water rights (value of water rights	15 000	141	2 115 000
Value of developed irrigable land	1 000	30	30 000
Flood irrigation system vines	15 000	*170*	2 550 000
Total value of irrigation	**31000**		**4 695 000**
Current debt (short, medium & lon			0
Collateral value of irrigation farm			**4 695 000**

Per hectare level crop analysis results:

				Initial Capital	NPV 5%	NPV 8%	NPV 12%	IRR
Maize	Without Drainage	GM	R/ha	0	*30 259*	*23 464*	*17 459*	
	With Drainage	GM	R/ha	-14 286	*37 249*	*26 315*	*16 603*	*28.8%*
	Incremental	GM	*R/ha*	-14 286	***6 991***	***2 852***	***-856***	**10.9%**
Cotton	Without Drainage	GM	R/ha	0	*8 658*	*6 821*	*5 190*	
	With Drainage	GM	R/ha	-14 286	*24 906*	*16 591*	*9 205*	*21.6%*
	Incremental	GM	*R/ha*	-14 286	***16 248***	***9 770***	***4 015***	**16.3%**
Lucerne	Without Drainage	GM	R/ha	-5 000	*4 673*	*2 497*	*580*	
	With Drainage	GM	R/ha	-19 286	*55 659*	*39 759*	*25 634*	*31.0%*
	Incremental	GM	*R/ha*	-14 286	***50 987***	***37 262***	***25 054***	**37.3%**
Vines	Without Drainage	GM	R/ha	0	*-24 489*	*-19 488*	*-15 034*	
	With Drainage	GM	R/ha	-94 286	*-92 608*	*-95 521*	*-97 862*	*#NUM!*
	Incremental	GM	*R/ha*	-94 286	***-68 119***	***-76 032***	***-82 828***	**-4.6%**
Wheat	Without Drainage	GM	R/ha	0	*9 957*	*7 844*	*5 968*	
	With Drainage	GM	R/ha	-14 286	*11 379*	*5 934*	*1 097*	*13.2%*
	Incremental	GM	*R/ha*	-14 286	***1 422***	***-1 910***	***-4 871***	**6.1%**
Wht-Mz	Without Drainage	GM	R/ha	0	*32 651*	*25 442*	*19 062*	
	With Drainage	GM	R/ha	-14 286	*53 591*	*39 190*	*26 398*	*38.1%*
	Incremental	GM	*R/ha*	-14 286	***20 940***	***13 748***	***7 336***	**20.3%**

Figure 3.10. Page 2 of the farm-level analysis scenario model exampled (OV case study farm)

3.8 Suggested actions

It is suggested that the farmer works through these models and adapts them for his/her own specific circumstances, understanding what he/she is doing and using area specific variables where necessary. The interactions between the various components are very important.

4. REGIONAL / WUA LEVEL SALINITY AND DRAINAGE MANAGEMENT DECISIONS

This aim of this chapter is to move from individual farm to multiple farm / WUA / regional level analysis. The skills required for this level of analysis are also more advanced than for basic farm level analysis, and are more financial than bio-physical, although a good understanding of the bio-physical is also required. This regional level analysis builds on many aspects of the farm level analysis.

This chapter starts with an introduction defining the various service providers identified to set up and use the models described later in the chapter. The data requirements for setting up the models are listed, and after defining the various models, the model results are given and discussed for various scenarios. As the simulation models do not account for any externalities, the management of returnflows and the risks and responsibilities of drainage water disposal at a regional level are discussed.

Apart from the bio-physical and financial data required for setting up the models, the capacity sharing process revealed various other data and technical assistance needs of farmers, service providers and policy makers, which are discussed. The chapter end with various suggested roles and action for the various stakeholders identified.

4.1 Introduction

Service provider is used in this report to encompass the broad group of people/institutions who provide direct service to the farmer. The main groupings of irrigation service providers are as flows:

a. Input suppliers (co-ops/agri-businesses, chemical companies, irrigation equipment suppliers, etc).

b. Service provider specialists (management consultants, irrigation & drainage engineers, technicians, etc).

c. Financial institutions (commercial banks, Land Bank, etc).

d. Local institutions (WUA, DoA, DWAF).

Farmers need technical, financial and government assistance to manage salinity and water-logging on their farms to remain financially viable.

Although the models presented in this section are policy level models, a co-ordinated combination of a team of various service providers to collect the data for the models, input the data, run the models and interpret the models for feedback to policy makers, is required. To quote a salinity policy expert form Australia, Steven Dovers (2008)*: "One lesson from the history of salinity is that scientific or even community knowledge is insufficient to ensure action, and that the complicated world of policy, politics and institutions is where the real challenge lies."* This chapter therefore aims to identify the various role-players responsible, and their tasks to supply the necessary data to policy makers to assist farmers equitably and efficiently to restore and conserve the precious soil resource base.

4.2 Data needs for effective salinity and water table management – suggested methods

4.2.1 Models

Basic farm level models for use by farmers to help understand salinity and to get an idea of the salinity processes on their farms are explained in Chapter 3. In this chapter the models explained are for set-up and use by service providers (Banks, WUA's, DWAF / DoA staff) to help guide/recommend funding and policy decisions.

4.2.1.1 Drainage costs calculation

Table 4.1 shows the steps in calculating the costs of complete infield area drainage with the pipe spacing required based on the soil clay percentage. This table only serves as a guideline and necessary irrigation scientists needs to be consulted to determine field specific spacing requirements.

Table 4.1. The calculation of the costs of artificial drainage installation based on expert opinion from Reinders (2005) and Van der Merwe (2005) C:\...\Drainage costs calc..xls

	Unit		Minimum spacing	Average spacing	Maximum spacing
Inter row spacing distance (meters) of different soil types for effective drainage:					
Heavy soils (>35% clay)	meters		20	25	30
Medium soils (15-35% clay)	meters		40	45	50
Light soils (<15% clay)	meters		70	75	80
The total meters of drainage required per hectare :					
Heavy soils (>35% clay)	m/ha		500.0	400.0	333.3
Medium soils (15-35% clay)	m/ha		250.0	222.2	200.0
Light soils (<15% clay)	m/ha		142.9	133.3	125.0
Cost of installing drainage	***R/m***	***100.00***			
Total cost per ha of drainage on different soil types:					
Heavy soils (>35% clay)	R/ha		50 000.00	40 000.00	33 333.33
Medium soils (15-35% clay)	R/ha		25 000.00	22 222.22	20 000.00
Light soils (<15% clay)	R/ha		14 285.71	13 333.33	12 500.00

If one takes for example the maximum spacing on soils that are just bordering on medium to heavy (i.e. 30 meters between drains) and convert it to the meters of drainage pipe required per hectare, you get 333.3 meters. At R100 per meter to install drainage (Note: this is the 2005 price guideline before fuel price increases, etc.) this equates to R 33 333 per hectare to install the drainage.

4.2.1.2 Farm level models for use by service providers

The farm level model as shown in Figure 3.9 can be used by service providers to assist farmers with their drainage decisions and to feed information into a business plan for requesting funding.

4.2.1.3 When best to install drainage in the lifecycle of an irrigation scheme

This section gives a demonstration of when it is best to install drainage over the life of a scheme. The results show clearly that drainage is required, consistent with the recommendations of Armour (2007) and Viljoen *et. al.* (2006), but when is the best time to install drainage in the lifecycle of the scheme? This depends on various factors, of which flooding events plays an important role for natural salt leaching from a salinity perspective, but can contribute significantly to water-logging as shown in Figure 4.1 by a reduction in yield the year of the flood (water-logging) and an increase in yields directly after the flood (natural leaching). Generally best results are obtained when the drainage is installed at the outset of the scheme. Furthermore drainage acts as an important buffer for management mistakes inevitable with any new farmers, or commercial farmers who may over irrigate in fear of electricity shortages, etc.

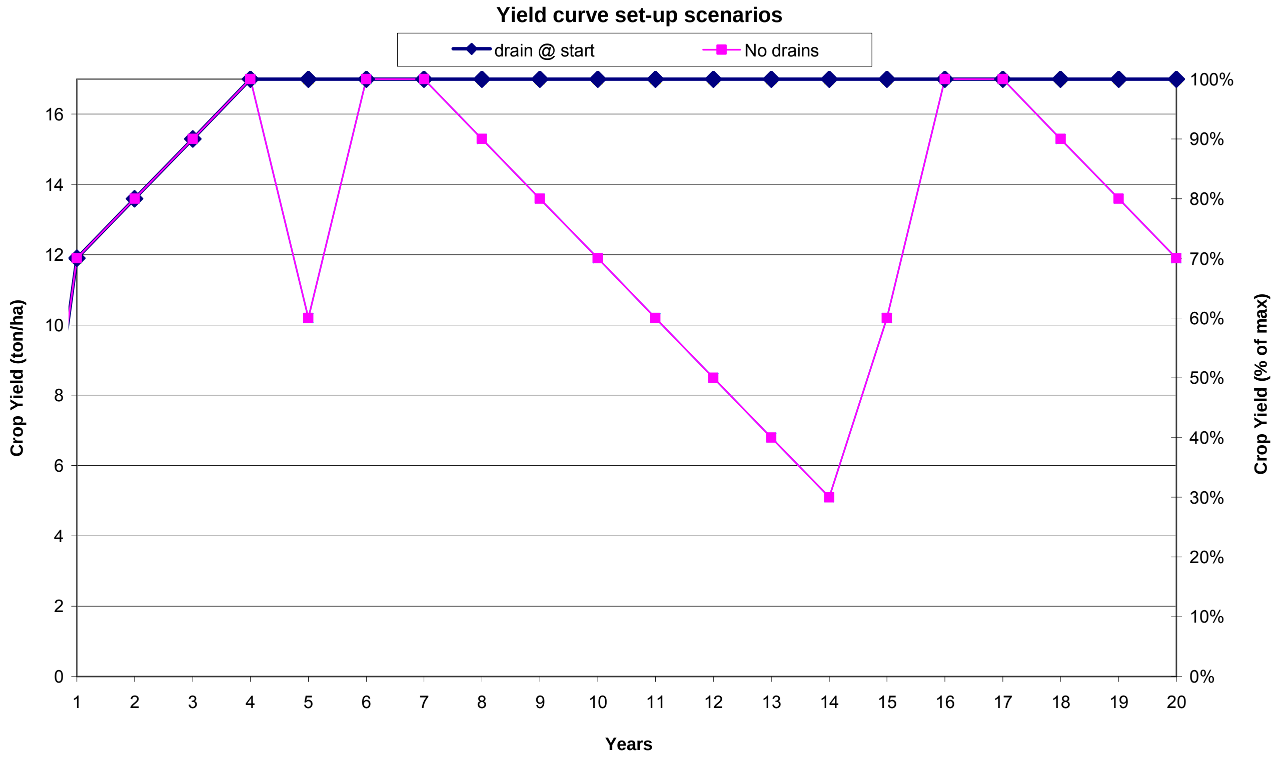


Figure 4.1. A yield curve for wheat and maize (1 ½ crops per year) with and without drainage with a 1 in 10 year flood occurring in years 5 and 15

Table 4.2 is a list of the main variables used in setting up the fictitious yield curves in Figure 4.1 for crops with and without drainage, used to demonstrate the interaction between floods, water-logging and salinisation.

Table 4.2 The main variables used in setting up the model

Farm size	ha	30	
Flood	years	1:10	
Capital costs			Term (years)
Macro infrastructure	R/ha	40 000	40
On farm infrastructure	R/ha	60 000	20
Drainage costs	R/ha	20 000	20
Loose capital	R/farm	250 000	5
Loose capital repayment	R/ha	2 398	
Operational costs			
Input costs	R/ha	18 000	(1 1/2 crops / yr)
Max potential yield	ton	17	
Crops ave. price	R/ton	2 000	
Discount rate		6%	

This model assumes the total area needs to be drained – in reality however only portions will need drainage and those portions are not easily predictable beforehand, and thus it is often the decision to implement a scheme without drainage and only install the drainage when signs of salinisation and water-logging start to occur. Yields in the analyses are assumed optimal with regards to salinity and water-logging and input costs are assumed without the costs of drainage. Crop enterprise budgets have been drawn up in Table 4.3 for with and without drainage for some of the main crops planted in the area analysed.

Table 4.3 A crop enterprise budget analysis of the value (R / ha) of drainage *(with additional costs due to drainage shown in highlighted rows)*

Directly allocatable costs	Item	Wheat	Maize	Lucern1	Lucern2+	Potatoes
Marketing costs	Agents Commission & reg. fees					3 900.00
Labour	Permanent labour allocated					120.00
	Casual Labour					201.24
Fuel	Diesel	525.64	345.31	299.34	895.89	1 401.03
Fertilizers	Macro-elements	3 272.00	4 118.00	2 212.00	2 212.00	6 504.00
	Micro-elements	113.96	198.18	112.90	189.36	662.90
Chemicals	Insecticides	559.51	208.19	5.10		5 694.69
	Herbicides	102.27	704.52	832.58		402.48
Seed / Seedlings	Seed	720.00	1 383.75	1 500.00		14 720.00
	Seed preparation			214.50		
Pollination						
Crop insurance		1 108.38				
Irrigation costs	Electricity	513.00	621.00	880.32	1 148.40	576.00
	Electricity +leaching	538.65	683.10	924.33	1 205.82	633.60
	Water costs	359.97	421.59	685.78	805.83	404.18
	Water costs +leaching	377.97	463.75	720.07	846.12	444.60
	Scheduling costs	40.00	40.00	40.00	40.00	40.00
Repair & Maintenance	Mechanisation	336.64	152.07	1 055.61	1 055.61	754.84
	Irrigation equipment	198.00	198.00	198.00	198.00	198.00
	Drains (R150 / ha / year)	99.00	99.00	150.00	150.00	75.00
Harvesting costs	Packaging			196.43		3 732.00
	Harvesting	420.00	500.00	1 122.19	261.90	1 006.20
	Transport	260.00	480.00	600.00	800.00	8 320.00
TOTAL Variable costs		**8 529.38**	**9 370.61**	**9 954.74**	**7 607.00**	**48 637.56**
TOTAL Variable costs with drainage		**8 672.02**	**9 573.87**	**10 183.05**	**7 854.71**	**48 810.57**
Leaching fraction		*5%*	*10%*	*5%*	*5%*	*10%*
Rotation crops percentage of year		*66%*	*66%*	*100%*	*100%*	*50%*
Crop Price		2 940	1 200	800	800	2 180
Current yield (no drains)		6.0	8.0	10.0	15.0	25.0
Yield with drains (commercial)		6.5	12.0	15.0	20.0	40.0
TOTAL income (no drains)		17 640	9 600	8 000	12 000	54 500
TOTAL income (with drains)		19 110	14 400	12 000	16 000	87 200
Gross Margin		**9 111**	**229**	**-1 955**	**4 393**	**5 862**
Gross Margin with drainage		**10 438**	**4 826**	**1 817**	**8 145**	**38 389**
		Calculation of the annual repayment costs of drainage:				
Cost of drainage	R/ha	20 000				
Term	Years	20				
Interest rate	%	13%				
Repayment cost of drainage	**R/ha/yr**	**-2 847**				
Drainage margin	(GM drains - GM no drains)	**1 327**	**4 597**	**3 772**	**3 752**	**32 527**
Returns to drainage		**-1 519.72**	**1 749.67**	**924.62**	**905.21**	**29 679.91**

Cash flow results show that for crops that are not too sensitive to salinisation (i.e. wheat) drainage is not viable, but for crops that are moderately sensitive, direct returns can cover the annual drainage repayment costs for R20 000 /ha initial drainage costs.

The net present value (NPV) results in Table 4.5 clearly show that drainage is required (negative NPV with no drains at 6% discount rate). When comparing drainage from the beginning, drainage in year 5 and drainage in year 10, drainage from the beginning yields the best NPV but the IRR is lowest.

Table 4.4 Cash flow values (R/year) for various drainage options with 13% negative balance and 6% positive balance annual interest rates

Year	0	1	2	...	13	14	15	...	20
No drains	-100 000	-109 598	-117 044	...	-258 399	-299 791	-336 364	...	-538 269
With drains from beginning	-120 000	-132 198	-142 582	...	-32 124	-4 698	26 293	...	213 327
With drains after year 5	-100 000	-109 598	-117 044	...	-17 371	11 973	44 293	...	237 416
With drains after year 10	-100 000	-109 598	-117 044	...	-13 208	16 677	49 279	...	244 088

The cost benefit analysis approach is the standard approach for evaluating long term investments, so although the cash flow analysis yields a better positive value after 20 years for drainage installed latest (Table 4.4), the NPV from the Benefit/Cost Analysis (Table 4.5) show that installing in the beginning yields the most efficient financially feasible results.

Table 4.5 Financial analysis results at a 6% discount rate

Discount rate = 6%	Net Present Value (R)	Benefit/Cost ratio	Internal Rate of Return
No drains	-14 271	0.95	3.97%
With drains from beginning	139 734	1.6632	15.13%
With drains after year 5	135 713	1.6616	15.71%
With drains after year 10	133 265	1.6605	15.89%

The effect of not draining is clearly evident form year 7 onwards in Figure 4.1 with the cumulative cash flow deteriorating exponentially.

4.2.1.4 Comparing different case study farms to the same set of policy / management actions: Regional analysis model

Figure 4.2 is set up so that the effect of the same set of policy variables can be seen on different selected case study farms simultaneously so that national policy suggestions can be tested so as not to overly benefit some stakeholders and not effectively help those who need it most. It is important to realise not to penalise good farmers by creating disincentives for effective production, while poor (bad) farmers keep getting support.

Multi-region drainage policy analysis model		Water quality scen.	1			
Main regional differences:	% farm	78%	28%	9%	44%	
		LO	OV	OR	RN	
Area requiring drainage	ha	58.0	40.0	15.0	20.0	
Total drainage costs per ha	R/ha	R 30 000	R 30 000	R 30 000	R 30 000	30 000
Total debt / drained area (R'000)	tot. area	-2 633	-3 340	-760	-400	
Main Variables:		LO	OV	OR	RN	
Drainge loan interest rate	%/anum	16.00%	16.00%	16.00%	16.00%	16.00%
Bank Bal. interest rate		16.00%	16.00%	16.00%	16.00%	16.00%
Current total farm debt	R/farm	-2063428	-947518	-67059	-177778	y
GRANT for drainage	%	0.00%	0.00%	0.00%	0.00%	0%
Current cropping composition:		LO	OV	OR	RN	
Maize	ha	0	0	0	12	
Cotton	ha	8	0	0	0	
Lucerne	ha	3	40	15	0	
Vines	ha	47	0	0	0	
Wheat	ha	0	0	0	8	
New cropping composition:		LO	OV	OR	RN	
Maize	ha	0	0	0	12	
Cotton	ha	8	0	0	0	
Lucerne	ha	3	40	15	0	
Vines	ha	47	0	0	0	
Wheat	ha	0	0	0	8	

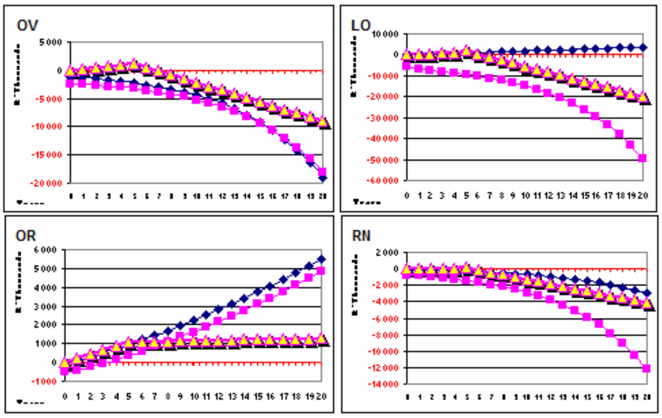
KEY:

Case study regions:

- LO Lower Orange River case study farmer
- OV Orange Vaal case study farmer
- OR Orange Riet case study farmer
- RN Orange Riet new case study farmer (emerging farmer)

Cash flows:

- Current situation
- Additional drainage
- Additional drainage & bridging f



Results:	IRR				NPV 5% (R'000)				NPV 8% (R'000)				NPV 12% (R'000)			
	LO	OV	OR	RN	LO	OV	OR	RN	LO	OV	OR	RN	LO	OV	OR	RN
Current situation	-	-	-	-	1 694	187	2 426	37	1 355	100	1 895	31	1 048	23	1 424	26
Additional drainage	8.47%	16.31%	41.43%	-1.55%	2 186	1 591	2 188	-284	242	956	1 612	-351	-1 455	393	1 101	-411
Additional drainage & bridging financ	2.27%	0.42%	36.33%	#DIV/0!	-1 590	-820	1 860	-947	-2 776	-1 144	1 354	-911	-3 801	-1 432	904	-879
Incremental - current & new scenari	5.80%	16.78%	-2.51%	-2.48%	492	1 404	-238	-321	-1 113	856	-283	-382	-2 503	369	-323	-437
Best performing crops pre drain	GM/ha				Vines	Wht-Mz	Lucerne	Lucerne	Vines	Wht-Mz	Lucerne	Lucerne	Vines	Wht-Mz	Lucerne	Lucerne
Best performing crops after drainge	GM/ha				Vines	Lucerne	Lucerne	Lucerne	Lucerne	Lucerne	Lucerne	Lucerne	Wht-Mz	Wht-Mz	Lucerne	Lucerne
Returns to gov. investment	492	1 404	-238	-321	1 337											

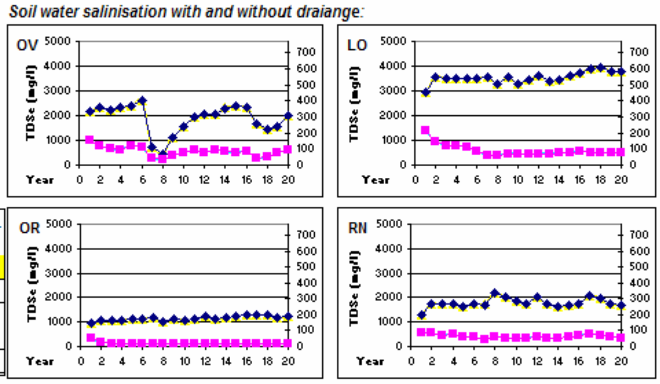
Figure 4.2. An example of the set up and results of the policy level model with no intervention

Figure 4.3 lists the basic crop and regional specifc set-up data used in the model as a reference base. The changing soil water salinities with and without drainage has already been discussed. Important is the block (bottom left) on policy results where the costs to the state of the proposed policy mix for support, fed into the model in Figure 4.2, is displayed. In this example there is not a grant and prime bank rates are paid for debt and drainage repayment, thus there is no contribution by the state.

Input data used:		LO	OV	OR	RN
Total crop input costs (R/ha)					
Maize	R/ha	6 229	5 813	6 161	6 777
Cotton	R/ha	10 574	10 248	10 481	11 529
Lucerne	R/ha	4 175	3 997	4 124	4 537
Vines	R/ha	7 780	7 519	7 705	8 476
Wheat	R/ha	5 646	5 386	5 705	6 275
Crop harvesting costs (R/ton)					
Maize	R/ton	72	96	71	78
Cotton	R/ton	280	280	280	308
Lucerne	R/ton	44	44	44	48
Vines	R/ton	270	270	270	297
Wheat	R/ton	87	103	103	114
Crop water requirement (mm)					
Maize	mm	1 022	749	749	749
Cotton	mm	1 027	753	753	753
Lucerne	mm	1 576	1 156	1 156	1 156
Vines	mm	824	604	604	604
Wheat	mm	820	601	601	601
Water charge	R/mm	0.77	0.35	0.82	0.82
Water rights	ha	74	141	170	45

		LO	OV	OR	RN
Crop Price (R/ha)					
Maize	R/ha	832	832	832	832
Cotton	R/ha	3 016	3 016	3 016	3 016
Lucern	R/ha	552	552	950	950
Vines	R/ha	1 063	725	725	725
Wheat	R/ha	1 208	1 208	1 650	1 650
Crop Yield (ton/ha)					
Maize	ton/ha	14.0	14.0	14.0	10.0
Cotton	ton/ha	5.0	5.0	5.0	4.0
Lucern	ton/ha	20.4	20.4	21.0	18.0
Vines	ton/ha	30.0	20.4	20.4	20.0
Wheat	ton/ha	7.0	7.0	7.0	6.0

Soil water salinisation with and without draiange:



POLICY RESULTS		LO	OV	OR	RN	TOTAL
Cost to state (drainage Grant)	R'000	0	0	0	0	0
Cost to state (subsidised interest)	R'000	0	0	0	0	0
	R'000	0	0	0	0	0
Increase in total output (5%DiscRate	R'000	492	1 404	-238	-321	1 337
Balance	R'000	492	1 404	-238	-321	1 337

Figure 4.3. The main input data used in setting up the model with policy results and soil water salinisation figure (upper line no-drainage, lower line with drainage).

Soil water quality, with and without drainage, for all three regions (OV, OR and OR=ORc and RN = ORn) is shown in Figure 4.3, together with the following crop and regional specific input data:

a. Total Crop Input Costs (R/ha)

b. Crop Harvesting Costs (R/ton)

c. Crop Water Requirmemnt (mm/ha)

d. Crop Price (R/ton), and

e. Crop Yield (ton/ha)

A Policy Results balance is also calculated in Figure 4.3 to compare the case study farm level drainage policy costs to the state with the increase in the direct value of production output as a result of drainage. The results in Figure 4.3 show that with the state support scenario drainage is econmically viable in the Lower Orange and Orange Vaal case study farms (CSFs), but not on the Orange Riet CSFs.

4.2.2 Model Results

The results of the model showed in Figure 4.2 are summarised in Table 4.6 and Table 4.7 where the NPV, the Farmers return to drainage and the IRR are shown for various levels of state grants.

Table 4.6. Model results showing the impact of Drainage Grant alone on NPV and the farmers return to drainage at a 6% discount rate.

Scenario	Drainage Grant:	NPV (R/ha) with drains LO	OV	OR	RN	Farmers Returns to drainage (6% Discount Rate) LO	OV	OR	RN
No-drains	0%	*27,025*	*3,855*	*148,443*	*1,750*	-	-	-	-
Drainage with no support	0%	25,060	33,814	131,468	-15,463	-1,966	29,959	-16,975	-17,212
Drainage Grant	50%	40,060	48,814	146,468	-463	13,034	44,959	-1,975	-2,212
Drainage Grant	60%	43,060	51,814	149,468	2,537	16,034	47,959	1,025	788
Drainage Grant	90%	52,060	60,814	158,468	11,537	25,034	56,959	10,025	9,788
Drainage Grant	100%	55,060	63,814	161,468	14,537	28,034	59,959	13,025	12,788

Table 4.6 shows that without drains, the four case study farms selected will have a positive NPV calculated over the next 20 years with the OR farmer by far doing the best. Installing drainage without any assistance results in all the farmers being worse-off except for the OV farm that has a positive return to drainage even without a grant or subsidised interest rate. At a 50% grant the picture only looks slightly better with the LO farm now showing positive returns. From 60% to the 100% grant all NPV and returns are positive.

Table 4.7. Model results showing the impact of Drainage Grant alone on the IRR

Scenario	Drainage Grant:	IRR LO	OV	OR	RN
No-drains	0%				
Drainage with no support	0%	8.5%	16.3%	41.4%	-1.6%
Drainage Grant	50%	10.4%	29.8%	72.6%	5.6%
Drainage Grant	60%	10.8%	35.2%	85.4%	8.5%
Drainage Grant	90%	12.3%	75.0%	181.4%	42.2%
Drainage Grant	100%	12.9%	120.0%	290.3%	n/a

Table 4.7 shows that the OV and OR farms can possibly afford to pay for drainage themselves. Thus it is advisable if the IRR is higher than the prime interest rate and the farmer have the necessary security, that the farmer install the drainage at own cost. The LO farm cannot afford to install drainage themselves even if a 100% grant was awarded. Only with a 90% grant can the RN farm afford to install drainage.

Table 4.8. 20 yr Cash Flow ending values of with and without drainage installed for various scenarios

Drainage Grant:	Current Debt:	Bridging Finance:	Debt Interest:	20 yr Cash Flow ending value - NO-DRAINAGE				20 yr Cash Flow ending values - DRAINED			
				LO	OV	OR	RN	LO	OV	OR	RN
0%	y		15%	65 553	-394 224	367 154	-126 413	-652 647	-345 907	323 726	-506 635
50%	y		15%	65 553	-394 224	367 154	-126 413	-407 149	-100 409	364 281	-261 137
90%	y		15%	65 553	-394 224	367 154	-126 413	-210 750	60 175	392 637	-64 739
50%	y		8%	65 594	-98 770	367 154	-34 119	80 330	59 362	364 281	-53 344
0%	0		15%	65 553	-6 534	367 154	4 071	-652 647	32 958	323 726	-361 155
50%	0		15%	65 553	-6 534	367 154	4 071	-407 149	116 140	364 281	-115 657
50%	0		8%	65 594	9 462	367 154	4 071	80 330	125 499	364 281	-11 914
50%	0	8%	8%	65 594	9 462	367 833	4 071	80 330	125 499	368 208	-11 914
90%	*y*	*10%*	*12%*	*65 553*	*-222 910*	*367 639*	*-73 150*	*17 738*	*79 975*	*393 411*	*160 552*
60%	*0*	*9%*	*10%*	*65 582*	*7 620*	*367 736*	*4 071*	*36 894*	*130 938*	*374 290*	*169 697*

Various combinations and levels of drainage grant, bridging finance and debt interest, and with and without current debt included, for four case study farms

Table 4.8 examines the cash flow ending values where no bridging finance is used – i.e. for in situation where a farm has sufficient remaining collateral to allow large negative cash flows / the area being drained in relation to the rest of the farm is small and the living costs of the farmer can be carried by the rest of the farm.

The results show without drainage that for most interest and debt combinations, the OV and RN farmers make a loss, while LO and OR farmers can continue without draining. With drainage installed LO is only economically viable with subsidised debt interest rates. Large drainage grants (90%) without subsidised interest rates do not help the LO high value, high capital intensive farm. Large Drainage grants without reducing debt interest rates do however help the OV farm obtain positive cash flow ending value.

The critical factor for the RN farm is that it is producing the wrong cropping combination – changing from wheat and maize in rotation to lucerne (shaded areas) produce much better results with drainage.

Table 4.9. Bridging Finance Cash flow ending values with and without drainage for various scenarios

Drainage Grant:	Current Debt:	Bridging Finance:	Debt Interest:	Cash Flow ending value - NO-DRAINAGE				Cash Flow ending value - DRAINED			
				LO	OV	OR	RN	LO	OV	OR	RN
50%	y	8%	8%	65 594	-98 770	367 154	-34 119	18 968	8 027	238 883	-35 873
90%	y	15%	15%	65 553	-394 224	367 154	-126 413	-147 113	-48 226	247 532	-37 764
0%	0	15%	15%	65 553	-6 534	367 154	4 071	-290 443	-65 808	104 201	-133 907
50%	0	15%	15%	65 553	-6 534	367 154	4 071	-210 815	13 820	183 829	-54 279
50%	0	8%	8%	65 594	9 462	367 833	4 071	18 968	68 734	238 883	-13 093
90%	*y*	*10%*	*12%*	*65 582*	*-222 910*	*367 639*	*-73 150*	*5 296*	*19 143*	*264 648*	*92 082*
60%	*0*	*9%*	*10%*	*65 582*	*-222 910*	*367 639*	*-73 150*	*17 738*	*79 975*	*393 411*	*160 552*

Various combinations and levels of drainage grant, bridging finance and debt interest, and with and without current debt included, for four case study farms

Table 4.9 consists of the cash flow ending values for a bridging finance scenario. The best policy option in general when making use of a bridging finance facility to cover existing debt is high levels of grant funding (90%) and higher interest rates (10% and 12%), or when not including current debt (only funding drainage), a policy mix of a relatively small grant of 60% but lower interest rates of 9% and 10% for the bridging finance and remaining debt respectively.

The policy mix that made all case study farms achieve a positive cash flow ending value with drainage installed and accounting for existing debt was a grant of 90%, bridging finance at 10% and debt financing at 12%. When not accounting for current debt, the grant can be reduced to 60% but the interest rates will also have to be subsidised at lower levels of 9% and 10% respectively.

4.3 Managing returnflows / Drainage disposal – risks and responsibility

It is important to take cognisance of the potential return on investment risks involved in awarding farmers a state grant / state supported bridging finance to install drainage. These include:

a. Downstream externalities rendering other farmers less productive

b. Poor maintenance of drainage leading to poor performance of the drains

c. Only planting low value crops and not realising greater returns from higher value crops necessary to justify the drainage grant / support.

d. Crop price volatility in the long term planning that could overstate potential benefits.

e. Natural disasters such as huge floods and earthquakes that could destroy the capital infrastructure.

4.4 Data and technical assistance needs of farmers, service providers and policy makers

Due to the lack of recorded soil salinity data over time, the use of more specialised models that are available is hampered and one is compelled to the use of simplistic assumptions in converting form irrigation water to soil water salinity for example. An investment in salinity mapping and a database to process and store soil salinity data is required.

4.5 Conclusion: Suggested actions

4.5.1 Engineers

There is a drastic shortage of suitably trained irrigation engineers in South Africa to sustainable implement a large-scale drainage programme. This will require serious action in providing incentives (bursaries) for young professionals and more attractive packages within the state departments to attract and keep irrigation engineers.

4.5.2 Banks

Financing of re-establishment of perennial crops and/or drainage will generally be done through the commercial banks. As these require large capital expenses thorough and realistic projections need to be made.

Banks should be careful of granting loans on farms that are becoming water-logged / salinised without the capacity for corrective actions. If funding is needed to establish a perennial crop, the salinity tolerance of the crop needs to be matched with that of the irrigation water supplied and that in the soil.

4.5.3 WUAs

WUAs have an important role to play, *inter alia* in coordinating drainage and leachate disposal options amongst farmers, monitoring water tables and quality of returnflows, etc..

4.5.4 Input suppliers

Fertilizer companies:

a. Should take regular soil samples to ensure the correct nutrients are applied.

b. When analyzing these soil samples ECe is usually determined. This is important information that can be entered into the soil salinisation database. Important however to note is that this information can be further enhanced if geo-referenced and samples are taken form the same site annually to determine ECe trends over time.

c. Where farmers are using saline irrigation water it is important to understand the effect on liquid fertilizers.

d. Furthermore, as these farmers will have to leach out the salts, the fertilizer companies will have to recommend fertilizers that do not readily wash out of the soils with leaching.

e. Where sodification has taken place in soils it is important that fertilizer companies recommend the correct lime / gypsum application to correct the SAR.

Co-operatives / agribusinesses:

a. The co-operatives / agribusinesses need to continue to provide irrigation scheduling services and to expand these to all members as these go a long way to prevent water-logging resulting from prolonged over-irrigation.

b. The co-operatives / agribusinesses already provide precision agricultural services to a limited paying clientele; this information is very valuable in identifying the areas with lower yields and analyzing them further to determine the specific reasons of the reduced yields.

5. SALINISATION AND WATER LOGGING POLICY GUIDELINES FOR THE LOWER ORANGE AND VAAL RIVERS

"One lesson from the history of salinity is that scientific or even community knowledge is insufficient to ensure action, and that the complicated world of policy, politics and institutions is where the real challenge lies." *Dovers, 2008*

The aim of this chapter is to provide the background information for a strategy for salinisation and water logging policy in the Lower Orange and Vaal Rivers.

To achieve this, this chapter starts a short literature review of salinisation and drainage, with some facts for policy makers to consider and some pertinent question and queries directed to government at stakeholder meetings.

Reviewing the applicable Act and Bills, a paragraph follows stating the Governments mandate for protecting the nation's soil and water resources from salinisation and water-logging. Further the alignment of salinisation and waterlogging management and support with the DoA Strategy Plan for 2008-2011 is also discussed.

The chapter then contains a section referring to the policy level research results in Chapter 4, various policy options available together with the policy recommendations from various other WRC research projects. The following policy recommendations are listed:

a. Reinstate subsidisation of irrigation drainage

b. Consider putting constraints on returnflows

c. Consider subsidisation of on-farm storage/evaporation ponds

d. Provision of laser-levelling and soil salinity mapping services

e. A drainage strategy, land retirement and data collection needs

5.1 Brief literature review of drainage policy

Wood (2008) in presenting the Global Salinity Report at the 2nd International Salinity Conference states that: Salinisation is a slow and certain white death, globally occurring at 3 hectares per minute or 1.5 million hectares per year. With 40% of global food being produced on irrigated land, of which currently 20% is affected by salinisation, this is a serious threat to already stressed global food production. Africa is the 2nd most salinised continent after Asia and Africa and Asia together account for 90% of the world's salinisation problems (Wood, 2008). These two continents are also the two where hunger and food insecurity are greatest. About 80 million hectares in Africa are deemed to be saline, sodic or saline-sodic (Taha, 2008)

Drainage investment to combat salinisation and waterlogging according to the World Bank (2005) make for "*a highly suitable instrument for broad-based rural development and integrated land and water resources management"*, very consistent with current political objectives in South Africa. Wood (2008) further states that economic costs is an area not well understood by the general public; These include financial cost (money), environmental costs and social costs.

Results of the WRC study by Viljoen *et al* (2006) clearly showed that the loss to the economy caused by salinisation alone was greater than the costs to remedy the salinisation by the installation of drainage. Put differently, the benefits of drainage exceeded the costs. Where waterlogging occurs greater losses can be expected and waterlogging is also a precursor to salinisation. Government clearly has a mandate to protect the nation's soil and water resources and ensure sustainable food production for its people.

The Viljoen *et al* (2006) report clearly shows that most farmers don't have the financial ability to install drainage without some form of assistance, threatening food production capacity. The question is therefore; who should get supported, how much should they get in support and what means of support works best?

5.1.1 Facts for policy makers to consider

a. *From the International Salinity Forum:* Globally, salinisation and water-logging of agricultural land is advancing at 3 hectares per minute, which equals 1.5 million hectares per year, currently affecting 20% of all irrigated land and thus threatening global food production, already a volatile issue.

b. At the Northern Cape Department of Agriculture Technology Transfer meeting drainage was proposed as a very effective means to increase productivity on irrigated land and that this fits in well with the LARP (Land and Agrarian Reform Policy) mandate by government to increase agricultural productivity by 10%. This comment is reinforced by the International Commission on Irrigation and Drainage (ICID) president, Peter Lee (Lee, 2007), listing drainage as one of the top 10 technologies for doubling food production: "*Drainage, an "old" technology but one which we must not forget can improve and sustain production in rather more parts of the world than irrigation on its own"*

c. In a meeting with Mr. H Grobler, chairperson of the FS-CCAW, Mr. Grobler referred to a current government project; the 50 ha Boitumelo vineyard project just outside of Jacobsdal that became waterlogged within 9 months of the establishment of new vineyards due to no drainage planning. He felt that it was important to inform all provincial departments of agriculture that drainage can be installed using CASP funds (but these are unfortunately only available for HDI farmers). He also suggested to co-ordinate closely with LandCare as a driver for drainage projects and that Public Private Partnerships be negotiated such as the FS-DWAF having a DBSA paid engineer assisting them.

5.1.2 Questions directed to government at stakeholder meetings

The following are comments listed and questions raised at the Technology Transfer Meetings held between February and April 2008, that may be of value to the government officials and planners responsible for land and water resource conservation and management to ensure sustainable and increased food production.

a. Jacobsdal farmers and service providers recognised the problem and the need for them to pro-actively take action but stressed the necessity of support from the relevant government departments in the form of technical expertise, grants, training and further research and development. These are not just for the benefit of new emerging farmers, but also for existing commercial farmers, the producers of the bulk of the countries food, who are also finding it more and more difficult to remain financially viable and productive on their own.

b. The Douglas farmers asked the question: If farmers go ahead and install drainage at their own costs, will they still be able to claim from a drainage subsidy if it is brought in at a later stage?

c. Upington farmers and service providers recognised the importance and urgency of actively managing salinisation and water-logging and not just sustaining, but regaining productive agricultural land through drainage. So much so that they suggested that a salinity and drainage management strategy document be submitted through the due political channels to be issued as a White Paper.

5.2 Governments mandate for protecting the nations soil and water natural resources

South Africa is often cited as having one of the most advanced water policies in the world, however nowhere in the National Water Act is pertinently referred to controls and measures for salinisation and waterlogging. These are only addressed in the draft Sustainable Utilisation of Agricultural Resources Bill. The following Bills and Acts *inter alia* point to the necessity of governments' involvement / responsibility in ensuring that soils do not become unproductive due to either salinisation or waterlogging:

a. The **Bill of Rights**, Chapter 2 in the **Constitution of South Africa** (1996) ensures that everyone has the right to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that: i.) prevent pollution and ecological degradation; ii.) promote conservation; and iii.) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

b. The **National Water Act** (39 of 1998) ensures that water resources are protected, used, developed, conserved, managed and controlled, to *inter alia* promote the efficient, sustainable and beneficial use of water.

c. The **Conservation of Agricultural Resources Act** (43 of 1993) provides for the conservation of natural agricultural resources by maintaining the production potential of land.

d. The draft **Sustainable Utilisation of Agricultural Resources Bill** (2003) pertinently refers to standards and control measures for the prevention or control of the water-logging or salinisation of agricultural land.

The WRC study by Viljoen *et al*, (2006) clearly indicates that the costs of drainage grants by the state are far less than the costs to the economy of the threat of declining food production and job losses resulting from salinisation and waterlogging of the agricultural resource base. In the light of the current substantial increase in food prices globally, local food production potential should be protected at all cost.

5.2.1 Aligning Salinisation and Waterlogging Management and Support with the Department of Agricultures Strategy Plan for 2008-2011

This paragraph discuss aligning the degradation of irrigation land caused by Salinisation and Waterlogging with the latest National Department of Agricultures (NDoA) Strategy Plan for 2008-2011.

Programme 4 of the NDoA (2008) Strategy Plan, titled Production and Resources Management (PRM), presented to the portfolio Committee on 12 March 2008 by Dr Sizwe Mkhize and to the Select Committee on Land and Environment, on 06 May 2008 by Dr Motseki Hlatshwayo states the following purpose:

To *"identify opportunities and develop strategies in order to optimise agricultural productivity and profitability within the agricultural sector through sustainable use and protection of land and water resources."*

The components of the programme consist of Agricultural Production and Engineering Services and Resources Management:

a. **Agricultural Production** *"facilitates improvements in agricultural productivity with the emphasis on sustainable animal, aquaculture and plant production systems and administers the Plant Improvement Act, 1976; Plant Breeders' Rights Act, 1976; and the Animal Improvement Act, 1998"*

b. **Engineering Services and Resources Management** *"facilitates the development of agricultural infrastructure and use of agricultural resources. This also includes auditing of natural resources, controlling migratory pests, rehabilitation and protection of agricultural land and promotion of the community-based Land Care Programme."*

The key result areas and measurable objective state:

To *"improve the efficiency of agricultural production for livestock, fisheries and crops, area-wide planning, mechanisation, irrigation development and the enhancement, conservation and rehabilitation of degraded natural agricultural resources."*

Engineering Services and Resources Management with a 2008-2011 allocated budget of R201 290 000 has the following Special Projects / Highlights, all of which are applicable or related to irrigation drainage installation:

a. Rehabilitation of Degraded Lands

b. Revitalization of Irrigation Schemes

c. Area-wide Planning

Targeted in this budget to achieve the above is the purchase of 200 power hoes as part of the Agricultural Mechanisation Programme and 100 000 ha of irrigation to be established / rehabilitated nationwide following certain unspecified guidelines for irrigation development.

Table 5.1 is a summary of NDoA (2008) Strategy plan sub-programme 4: Production and Resources Management.

Table 5.1. Strategy plan sub-programme 4: Production and Resources Management summary

Sub Programme	Output	Measure / Indicator	Target
Agricultural Production	Crop and livestock massification	Community gene banks Community seed production scheme Etc.	2 gene banks established 3 schemes established etc.
Engineering Services and Resource Management	Natural resources management and enhancement	Agricultural Mechanisation Programme Land Use Planning and Zoning Programme Guidelines for irrigation development	200 power hoes distributed 3 Local municipalities zoned 100 000 ha established/rehabilitated

Drainage is a very effective means to increase productivity on irrigated land. Peter Lee, (Lee, 2007) president of the International Commission on Irrigation and Drainage (ICID), states as one of the top 10 technologies for doubling food production, "*Drainage, an "old" technology but one which we must not forget can improve and sustain production in rather more parts of the world than irrigation on its own"*

Fitting in to the agricultural production component as an effective way of managing and utilising saline irrigation return flows is aquaculture which can be used for upliftment of HDI's and farm workers without impacting food production. This is a potential "win-win" opportunity that is being successfully implemented in Australia and California (see Figure 5.1)

Figure 5.1. Saline aquaculture as a potential HDI project utilizing irrigation returnflows from drainage *(picture taken by author, 2nd International Salinity Forum Field Trip, 2 March 2008)*

5.3 Research Results

It was confirmed in the farmer and service provider meetings (not just with the computer models), that drainage can dramatically increase the productivity of land.

The potential returns from the capital invested in existing infrastructure (physical capital) are lost if the resource base (natural capital) is diminished through either water-logging and/or salinisation.

LandCare was identified as a main driver from government for management and implementation of drainage. WUAs also have a vital role to play in identifying areas affected, the management of return-flows and data collection and dissemination.

As the policy level research is conducted and advised by service providers, the research results at policy level are displayed and discussed in Section 4.2.2.

5.4 Policy options

Kijne *et al.* (1998) state that because of the need for sustained and enhanced food production, the prevention, mitigation, and reversal of further degradation of soil and water resources in irrigated agriculture should be a first priority. One option is to uncouple water entitlements from the land and promote an active trade within a well defined water market so that economic forces can dictate that scarce water resources be applied on the best possible soils. A water market that includes a water quality dimension is a possible mechanism. Janmaat (2005) however warns to establish water markets before taxing environmental externalities, as only in the presence of properly functioning water markets can the incentives/disincentives created by taxing environmental externalities (i.e. irrigation drainage) produce the desired effect.

To be effective in addressing water management problems, Freinerman (2000) states that economists need to know the physical and biological relationships involved and integrate them into an economic model. Therefore the best way to promote effective water management is via collaboration among economists, and soil, water and plant scientists. One crucial strategic partner that Freinerman misses in the collaborative team is the civil servant, who takes the research results and recommendations to being implemented as effective policy.

5.5 Policy recommendations from various WRC research projects

Armour (2002) results clearly show that the small and resource poor farmers will be the most affected by irrigation water salinity deterioration. The discussion to follow are summaries of various WRC reports supporting the results of this consultation.

5.5.1 Reinstate subsidisation of irrigation drainage

No irrigation system is sustainable without sufficient drainage. Unless natural drainage up until below the root zone is sufficient and water tables aren't rising, artificial drainage has to be installed. Quoting Du Preez *et al, (*2000:154) "Results from these estimations (Szabolcs model) indicate that all the undrained soils will, due to excessive salt accumulation, become unsuitable for irrigation by approximately the year 2050." To reinforce this, Brady & Weil (1996:307) state, "If the irrigation system does not provide good internal drainage, soil salinity can increase to intolerable levels, as can the exchangeable sodium level. The latter engenders chemical and physical problems that, if not corrected, will render a soil virtually useless as a habitat for plants."

Subsidising irrigation drainage on its own however, will lead to the exacerbation of the water quality problem, especially in hydraulic systems such as in the Lower Vaal and Riet Rivers, because of the greater mobilisation of salts in the system facilitated through the artificial drainage.

A major advantage of managing / monitoring an irrigation system with irrigation drainage is that, what was a non-point / diffuse pollution source is now a point-source pollution problem that can be measured, monitored, and controlled and accordingly a possibility of imposing a waste discharge charge (WDC) system.

5.5.2 Consider putting constraints on returnflows

Subsidising irrigation drainage will lead to an increase in irrigation return-flows that in turn will increase the salinity levels in the rivers they flow into if controls aren't placed on irrigation return-flows. The environment is also not protected from the agricultural chemicals and salts that these return-flows would deposit into the river if not managed. Coupled with artificial drainage subsidisation there therefore has to be a constraint on agricultural return-flows and possibly also the subsidisation and promotion of on-farm management practises to manage irrigation return-flows.

Putting a limit on the volume of irrigation return-flows allowed might solve the river water quality problem but soil salinisation will proceed because the incentive for leaching is removed.

A waste discharge charge (WDC) system can only be effective where return-flows are point source – A model such a SALMOD can simulate the contribution of an irrigation practice to non-point source pollution, but the results will always be viewed sceptical and untrustworthy to the perpetrator.

5.5.3 Consider subsidisation of on-farm storage/evaporation ponds

In the US and Australia there are stringent controls on irrigation return-flows from being allowed to re-enter the water source. There are either canals that transport the irrigation return-flows to irrigation scheme managed evaporation basins or wetlands, or the farmers have their own evaporation ponds and / or practice serial biological concentration (SBC). In SBC the saline return-flows from a salt sensitive crop are used to irrigate a moderately tolerant crop, and the even more saline return-flows from this crop are used to irrigate salt tolerant crops (halophytes) or woodlots or are used for aquaculture. This promotes greater water use efficiency, but requires large capital expenditure and management expertise.

By implementing a policy to constrain return-flows, river and groundwater water quality will be improved and prevented from deteriorating further. Under these improved water quality conditions the return-flows from the resulting optimal crop compositions could be less than the maximum specified in the constraint, making the return-flows constraint no longer necessary once farmers are using and managing their on-farm storage dams properly. This constraint is however initially required to get farmers to install drainage and build on-farm storage dams. Constraining irrigation return-flows must be coupled with the incentives of artificial drainage subsidisation and on-farm storage dam subsidisation.

5.5.4 Provision of laser-levelling and soil salinity mapping services

The provision of laser levelling and soil salinity mapping services needn’t be state supplied, but entrepreneurial opportunity exists in supplying these services. The Orange Vaal Water Users Association or GWK Ltd. could provide the service or put out a tender.

Although the model didn’t show it was feasible to change the irrigation system for any case study farmer under any salinity scenario, it must be brought to the attention of irrigation system designers to make provision in new centre pivot irrigation systems for greater application capacities for the provision for sufficient irrigation leaching. This was identified as a problem in the study area in the Du Preez *et al, (*2000) report.

What wasn’t taken into account in SALMOD was the leaf wetting effects of sprinkler type irrigation systems. High concentrations of certain inorganic salts in the irrigation water can cause leaf scorching.

Although laser levelling and salinity mapping were not studied implicitly in this study, the latest literature and trends in salinity management reveal that these salinity management options are being widely used.

Laser-levelling for flood irrigation could provide a cheaper and very nearly as efficient method of irrigation as centre pivot irrigation without the leaf wetting effect and much greater capacities to leach. The installation of artificial drainage is also easier on a laser-levelled field.

Soil salinity mapping is conducted using a global positioning system (GPS) linked to an electrical conductivity field meter such as the Geonics EM-38 meter. The vehicle on which these instruments are mounted traverses the field taking regular bulk soil electrical conductivity (ECa) readings. These spatial readings are statistically processed to provide soil salinity contours. A soil sample is then taken from each contour grouping and analysed to get the ECa and ECe correlation. Soil salinity mapping provides infield identification of problem areas so that with remediation only the problem areas need to be managed and with regular soil salinity readings the effectiveness of a leaching management strategy on salinity control can be gauged.

Johnston (1994) warned that "*most of the irrigation schemes in South Africa are affected to some degree by soil salinity. This accumulation of salts in the soil is normally associated with water-logging that occurs primarily in the poorly- drained regions of the landscape. Salinisation usually develops insidiously over many years, and can present a serious threat to the long-term viability of an irrigation scheme. There is a need therefore to monitor trends in soil salinity levels on irrigation schemes.*" Not heading to this warning by Johnson (1994) made over 14 years ago, there is currently still no soil salinity monitoring process initiated and thus no reliable data on soil salinity trends.

5.5.5 Policy recommendations by Volschenk et al. (2005): Drainage strategy, land retirement and data collection needs

"The absence of a drainage management strategy for the area, as well as lack of appropriate policy to enforce installation of drainage or to retire land where excessive salinisation occurs, almost certainly hampered the management of surface water and soil salinisation. The development of such policy and integration with the water quality management strategy of DWAF is therefore seen as necessary to protect water and soil resources in the Lower Orange River WMA. Possible constraints for implementation of the management actions include the rate of the integrated water resource management transformation process by DWAF, the level of communication between relevant institutions and the availability of resources to provide, alter and maintain water delivery and storage infrastructure.

To ensure sustainable use of the water resource and to support future management decisions, there is a need for ongoing collection and interpretation of information and research on specific aspects, including the following:

a. For monitoring of water quality trends and salt balance calculations or systems modelling to support salinity management decision making, consistent monthly data collection, verification, processing and interpretation of surface water quality and water flow data are crucial.

b. For estimation of the impact of drainage water quality on surface water quality, collection of data on drainage water quality and quantity is necessary. Such information can be included in and managed similarly to the surface water database as described above.

c. For judicious installation of cut-off drains, detailed information on geo-hydrological characteristics of the catchments and sub-catchments is required.

d. *For estimation of the potential effect of catchment or sub-catchment characteristics on irrigation-induced ground water recharge, more research is necessary especially regarding soil water retaining properties and recharge rates.*

e. *Recharge rate is affected by water consumption of the irrigated crop and research is needed on the minimum water requirement of all crops produced in the lower Orange River WMA.*

f. *In order to obtain a better understanding of the salinisation mechanism operating in the lower Orange WMA, the contribution of salt by tributaries of the Orange River (e.g. the Sout and Hartebeest rivers) during periods of unusually high precipitation needs to be quantified.*

g. *Effective methods of technology transfer need to be developed to ensure that producers adopt a best practices approach with respect to irrigation scheduling and salinity management.*

h. *For an improved method to identify salinised irrigated areas from aerial survey images, an object-oriented approach should be researched."*

5.6 Summary and Conclusions

Globally there is a concern about the deterioration of irrigated land due to salinisation and water-logging.

This has led to recent World Bank studies calling for increased investment to protect our valuable soils and water resources.

The South African Government is also clearly mandated by various Bills and Acts to ensure the sustainable utilization of its precious soils and water resources.

The recent National Strategy Plan for Agriculture makes provision whereby drainage infrastructure can be installed within its objectives and mechanisms.

The research results show for the selected case study farmers selected, that unless a farmer has no debt he is not able to afford drainage and it may be costs effective for him to accept the reduction in crop yields due to salinisation and drainage if no financial assistance is available. Even the farmer without debt may require an incentive to drain as the returns to drainage yield less than investing the capital required for drainage at a bank for example.

The following policy options are suggested to facilitate the installation of drainage for effective salinisation and water-logging control to increase agricultural production and hence socio-economic welfare:

a. Reinstate subsidisation of irrigation drainage in the form of green box grants utilizing ASGISA funds

b. Consider putting constraints on returnflows to prevent downstream externalities especially during low flows

c. Consider subsidisation of on-farm / sub-area storage / evaporation ponds to control / manage returnflows during low flow seasons and cycles

d. Provision of laser-levelling and soil salinity mapping services to prioritise drainage investment and measure the effectively of the interventions.

e. A drainage strategy incorporating all of the above, land retirement where drainage is not economically viable and data collection, co-ordination and analysis for better management and evaluation.

A Proposed Plan of Action and Strategy stemming from these research results is presented at the end of Chapter 6.

6. SUMMARY, CONCLUSIONS & RECOMMENDATIONS

Cited in Williams (1999), Davies and Day (1998) regard salinisation of rivers as one of the major threats to South Africa's water resources. Williams (1999) further motivates policy action through acquisition of data and careful management; "*Salinisation can be contained only by informed water resource management. Without this, the prognosis for water resources in many semi-arid and arid regions is bleak.*"

6.1 Summary

This section summarises the main results of the consultation at case study farmer level, service provider level and at policy level:

6.1.1 Case Study Farmer level

The results of the combined case study farmer models are shown in Chapter 4, where the NPV, the farmers' return to drainage and the IRR are shown for various levels of state grants.

Results shows that without drains, the four case study farms selected will still have a positive NPV calculated over the next 20 years with the OR farmer by far doing the best. Installing drainage without any financial assistance results in all the farmers being worse-off except for the OV farm that has a positive return to drainage even without a grant or subsidised interest rate. At a 50% grant the picture only looks slightly better with only the LO farm now showing positive returns. From 60% to the 100% grant all NPV and returns are positive.

Results further show that the OV and OR farms can possibly afford to pay for drainage themselves. This is advisable only if the IRR to drainage is higher than the prime interest rate and the farmer has the necessary security, that he install the drainage at own cost. The LO and RN farms cannot afford to install drainage themselves even if a 100% grant was awarded, due to the vineyard re-establishment costs and current debt levels.

Without bridging finance:

Drainage without bridging finance is only possible in a situation where a farm has sufficient remaining collateral to allow large negative cash flows / the area being drained in relation to the rest of the farm is small, and the living costs of the farmer can be carried by the rest of the farm.

The results show that without drainage for most interest and debt combinations, the OV and RN farms make a loss, while LO and OR can continue without draining.

With drainage installed LO is only economically viable with subsidised debt interest rates. Large drainage grants (90%) without subsidised interest rates do not help the LO high value, high capital intensive farm to improve his situation with drainage. Large drainage grants without reducing debt interest rates do however help the OV farm obtain positive cash flow ending value.

The critical factor for the RN farm is that it is producing the wrong cropping combination – changing from wheat and maize in rotation to lucerne produce much better results with drainage.

Bridging finance scenario:

The best policy options when making use of a bridging finance facility to cover existing debt is high levels of grant funding (90%) with higher interest rates (10% and 12%), or when not including current debt (only funding drainage), a policy mix of a relatively small grant of 60% but lower interest rates of 9% and 10% for the bridging finance and remaining debt respectively.

6.1.2 Service provider level

Various actions are suggested for the different service providers involved in drainage planning, installation and financing.

Engineers - There is a drastic shortage of suitably trained irrigation engineers in South Africa to sustainable implement a large-scale drainage programme. This will require serious action in providing incentives (bursaries) for young professionals and more attractive packages within the state departments to attract and keep irrigation engineers.

Banks - Financing of re-establishment of perennial crops and/or drainage will generally be done through the commercial banks. As these require large capital expenses thorough and realistic projections need to be made. Banks should be careful of granting loans on farms that are becoming water-logged / salinised without the capacity for corrective actions. If funding is needed to establish a perennial crop, the salinity tolerance of the crop needs to be matched with that of the irrigation water supplied and that in the soil.

WUAs - WUAs have an important role in coordinating drainage and leachate disposal options amongst farmers.

Input suppliers - Fertilizer companies:

a. Should take regular soil samples to ensure the correct nutrients are applied.

b. When analyzing these soil samples ECe is usually determined. This is important information that can be entered into the soil salinisation database. Important however to note is that this information can be further enhanced if geo-referenced and samples are taken from the same site annually to determine ECe trends over time.

c. Where farmers are using saline irrigation water it is important to understand the effect on liquid fertilizers.

d. Furthermore, as these farmers will have to leach out the salts, the fertilizer companies will have to recommend fertilizers that do not readily wash out of the soils with leaching.

e. Where sodification has taken place in soils it is important that fertilizer companies recommend the correct lime / gypsum to correct the SAR.

Input suppliers - Co-operatives / agribusinesses:

a. The co-operatives / agribusinesses need to continue to provide irrigation scheduling services and to expand these to all members as this go a long way to prevent water-logging resulting from prolonged over-irrigation.

b. The co-operatives / agribusinesses already provide precision agricultural services to a limited paying clientele; this information is very valuable in identifying the areas with lower yields and analyzing them further to determine the specific reasons of the reduced yields.

6.1.3 Policy level

Policy options are suggested to facilitate the installation of drainage for effective salinisation and water-logging control to increase agricultural production and hence socio-economic welfare. These are included in the Recommendations (Proposed Plan of Action / Strategy) in paragraph 6.4.

6.2 Conclusions

To convince farmers that drainage is important, the experience of the researchers aligns with the words by Taha (2008): "You only need to convince 1 or 2 good / leader farmers, thereafter seeing is believing". The premise is that once leader farmers drain and the results are evident, other farmers will take notice and drain themselves. The problem with this however is that leader farmers often have the financial resources, whereas others who look on may be convinced that drainage will work and have the will to drain, but not the finances.

It is important to take cognisance of the potential return on investment risks involved in awarding farmers a state grant / state supported bridging finance to install drainage. These include:

a. Downstream externalities rendering other farmers less productive

b. Poor maintenance of drainage leading to poor performance of the drains

c. Only planting low value crops and not realising greater returns from higher value crops necessary to justify the drainage grant / support.

d. Crop price volatility in the long term planning that could overstate potential benefits.

e. Natural disasters such as huge floods and earthquakes that could destroy the capital infrastructure.

The following are the main conclusions at case study farmer, service provider and policy level:

6.2.1 Case Study Farmer level

The policy mix that made all case study farms achieve a positive cash flow ending value with drainage installed and accounting for existing debt was a grant of 90%, bridging finance at 10% and debt financing at 12%. When not accounting for current debt, the grant can be reduced to 60% but the interest rates will also have to be subsidised to lower levels of 9% and 10% respectively.

6.2.2 Service provider level

It is important that the various service providers coordinate and align amongst themselves to be relevant at meeting the farmers needs by utilising the policy incentives available and actively directing and influencing policy further. This can be achieved through collaboration with researchers *inter alia* at the universities and the Water Research Commission.

6.2.3 Policy level

The conclusions of the policy level analysis are included as recommendations in the next paragraph.

6.3 Recommendations (Proposed Plan of Action / Strategy)

Serious and concerted local action is required to further identify and raise the awareness of the salinisation and drainage threat; and political action and support is urgently needed to help curb further resource degradation through drainage, and to regain the productivity of already salinised and waterlogged areas. This can be achieved through *inter alia* drainage grants, debt consolidation and subsidised bridging finance mechanisms for existing debts and additional drainage financing costs. An effective data measurement, analysis and communication programme together with local suitably trained irrigation service providers and technicians are also required as precursors for effective implementation and evaluation.

6.3.1 "Green box" drainage grants

The economic models concluded that drainage is economically viable in many situations for salinity and water-logging management. The financial models however concluded that, although economically viable, unless the farmer has no initial debt, drainage is not financially feasible. Furthermore, awarding a drainage grant will be necessary to incentivise most farmers to drain.

6.3.2 Debt consolidation and subsidised interest rates

In some cases a drainage grant alone was not sufficient, nor as effective as a policy instrument as subsidising the repayment interest rate of the loan. In the worst case study the only way that the farmer could continue farming and remain financially feasible was if his current debt, together with re-establishment and drainage costs were consolidated and repaid at a subsidised interest rate.

6.3.3 Monitoring and data

Water-logging and salinity data collection, population of a database and an effective communications programme was agreed to be necessary at all the meetings. Unfortunately the simplified farmer level methodology used and presented was turned down as it was agreed that most farmers wouldn't have the time to do it, although they were interested in having the information. The aim of the Department of Soil Science at the UFS's current project to commercialise an EM38 ECe mapping device for an Oppermansgronde entrepreneur was mentioned and received with optimism.

6.3.4 Training for Irrigation service providers and technicians

The important role of WUA's for scheme level drainage management was realised and their need for support, training and personnel. In all the farmer and service provider meetings it was mentioned that there is a desperate shortage of trained irrigation service providers and technicians to assist with drainage planning and monitoring of salinity and water-logging.

6.4 Technology Transfer Conference Presentations and Journal Articles

Besides the meetings and workshops held with various target groups and stakeholders and intensive meetings with the case study farmers at various stages of this consultancy, four conference presentations were made and two journal articles published / in preparation that also reached a wide academic and service provider audience.

Conference Presentations:

ARMOUR, R.J. & VILJOEN, M.F. (2007) To drain or not to drain? Quantifying the value of "Green Box" grants required to ensure the sustainability of irrigation: a case study of Friarsdale in the Lower Orange River. AEASA 2007 "From policy reform to implementation and delivery in South African agriculture". 26-28 September, Indaba Hotel, Johannesburg.

ARMOUR, R.J. & VILJOEN, M.F (2007) Salinisation - A Potential Poverty Trap without Drainage Grants: A Case Study in the Orange-Riet Water Users Association. ICID 2nd African Regional Conference, 6-9 November 2007, Glenburn Lodge, Johannesburg, South Africa.

ARMOUR, R.J. & VILJOEN, M.F. (2007) Salinisation: The Arid & Semi Arid Area Irrigation Threat. An Economic Case for Drainage & Leaching using Case Studies in the Orange and Vaal Catchments of South Africa. SADC Land and Water Management Programme Scientific Symposium Gaborone, Botswana, 20 - 22 Feb 2007. Paper accepted for presentation and included in the conference proceedings, but conference not attended.

ARMOUR, R.J. & VILJOEN, M.F. (2008) An economic case for drainage & leaching for salinisation control in the Orange-Riet and Orange-Vaal Water Users Associations of South Africa. 2nd International Salinity Forum, 31 March – 03 April 2008, Adelaide Australia.

Academic Journal Articles

ARMOUR, R.J. & VILJOEN, M.F. (2007) An Economic Case for Drainage for Sustainable Irrigation: Case Studies in the Lower Vaal and Riet Catchments. *South African Journal of Economic and Management Sciences.* NS Vol.10 No.4 December 2007.

ARMOUR, R.J. & VILJOEN, M.F. (in preparation) An economic case for drainage & leaching for salinisation control in the Orange-Riet and Orange-Vaal Water Users Associations of South Africa. The Australian Journal of Agricultural and Resource Economics.

Popular Journal Articles

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For a comprehensive list of all literature used in the authors PhD thesis see ARMOUR, R.J. (2007) Integrated Modelling For Sustainable Management of Salinity in the Lower Vaal and Riet River Irrigation Areas. Ph.D. Thesis. University of the Free State, Sasol Library, Bloemfontein. http://etd.uovs.ac.za/cgi-bin/ETD-browse/view_etd?URN=etd-12102007-075814

7. APPENDIXES

APPENDIX 1. BASIC MODELS EXPLANATION

These models are available electronically or on a CD from the WRC, or on the following website: www.ufs.ac.za/salinity

Box 1 lists the models, technology transfer MS Power-Point material and the recordings of the technology transfer meetings held, saved to the CD accompanying this report.

Box 1. The file names, types and size as found on the report CD

Name	Size	Type
Basic demo model - FARMERS	146 KB	Microsoft Excel Worksheet
Salt accumulation potential	16 KB	Microsoft Excel Worksheet
When to drain	50 KB	Microsoft Excel Worksheet
080213 DoA NC	2 314 KB	Microsoft PowerPoint Presentation
080218 TT Pres Farm & Tech	3 875 KB	Microsoft PowerPoint Presentation
080402IntSalForum-ARMOUR	3 026 KB	Microsoft PowerPoint Presentation
080506 Report on Technolog...	12 403 KB	Microsoft Word Document
0804UpingtonTT	85 879 KB	MPEG Layer 3 Audio
080415JacobsdalTT	69 648 KB	MPEG Layer 3 Audio
080415JacobsdalTT1	27 508 KB	MPEG Layer 3 Audio
080415JacobsdalTT2	40 960 KB	MPEG Layer 3 Audio
080417DouglasTT	15 328 KB	MPEG Layer 3 Audio
080418 UpingtonTT3	32 420 KB	MPEG Layer 3 Audio

FARMER LEVEL:

Basic demo model – FARMERS – to illustrate the salt buid-up potential with no drainage, in terms of tons of salts assed per hectare to your land

TECHNICIAN LEVEL:

Drainage costs calc. – a basic template

Salt accumulation potential – showing the effect of salinisation potential as a function of irrigation quota and evapotranspiration

POLICY LEVEL:

The policy level model is not available on the CD but can be requested from the authors.

APPENDIX 2. WRC REPORT PRESENTATION & MEETINGS REPORT

This Appendix gives the results from the WRC report by Viljoen *et al.* (2006) as presented to the stakeholders in the first round of meetings and workshops as part of the Technology Transfer consultation.

The PowerPoint presentation presented at the initial workshops and meetings were all generally the same, so only one presentation is included in the CD, namely :

C://…/061113 TT LO-NC expert panel meeting

The following meetings were held:

Date:	***Group / Where:***	***Present:***
26 September 2006	National DoA - Pretoria	Mr AT van Coller, Mr J Mulder, Dr GR Backeberg, Prof MF Viljoen
02 October 2006	Orange-Riet (OR) Stakeholders Presentation	GWK farmers Day - ±20 farmers / service providers
04 October 2006	Orange-Vaal (OV) Stakeholders Presentation	OV-WUA group meeting - ±30 farmers / service providers
20 October 2006	Organised Agriculture, Vrystaat Landbou *Watersake Komitee*	Mr K Nel (Committee Chair and Chairman of the Orange-Riet WUA), Mr G Teseling (Committee vice Chair & Orange-Riet Canal farmer), Mrs W Green (VS Landbou), Mr N Opperman (AgriSA), Mr N Knoetze (Orange-Riet WUA), Mr B Bardenhorst (Kalkfontein WUA), Mrs M Lombaard (Tierpoort WUA), Mr A Otto (Sand-Vet WUA), Mr M de Wilde (Vaal Dam WUA / DWAF), Mr P van Heerden and Mr P Pretorius.
13 November 2006	Lower Orange (LO) Stakeholders Workshop	Hannes Gerber (DoA), Leon Tereblanche (DoA), Nico Toerien (DoA), Pottie Potgieter (DoA), Dirk Malan (Farmer), Leon Laubsher (SAD/Pioneer foods), Mpho Lesesa (DoA), Anette Swanepoel (DoA-Upington Ass.Dir. Crop Production)
15 November 2006	FS CCAW – Glen, Bloemfontein (FS DoA & DWAF)	Mr J du Randt (Chair and FS DoA), Mr N Knoetze (OR WUA), Mr J Koch (Orange-Riet DoA), Mr A Fourie, Mr Mosholi, Mr GP Hadebe (DoA Welkom), Mr MTD Marumo, Mr D Visser, Mr G Madiba (Sasiledabe Kroonstad), Mr J Kegakilwe (Dir. Agric. Motheo District) and Mr M Groenewald (FS DWAF)
6 December 2006	NC DoA, Kimberley	Mr V Mothibi, Mr P de Bruyn, Me J Maisela, Me B Burgess, (Dr?) R “Doc” Moerane

Meeting feedback & results:

This first phase of the technical transfer process succeeded in raising the awareness of the results of the completed WRC report. It has informed the key stakeholders of the further plans of developing a financial farm level model, and has successfully obtained the buy-in of these stakeholders for the further developments.

Meeting interaction and feedback with the stakeholders resulted in important strategies for the farm level financial model development, namely:

1) to rather target extension officers and industry stakeholders (drainage installers, financiers, input suppliers, extension officers, etc.) to operate the farm level model instead of the farmers themselves
2) the farmers only need to be made aware of the results of the farm level models, with care to choose case study farmers that are known by the farmers. This has been done and case study farmers have been identified and approached for each study area.
3) The most effective means of reaching the farmers is to write articles in the local print media (newspapers) and weekly magazines.

Next phase: Because of *inter alia* the stabilising impact on national food security by irrigation produced food and the job creation potential in otherwise very marginal agricultural areas of the country, high capital investments are made in irrigation schemes leading to whole irrigation based industries and communities. If and when these schemes become unsustainable due to initially unforeseen events, such as salinisation, the socio-economic and environmental impacts could be disastrous. Salinisation at field level is however easily remediable, however it is also costly. As salinisation occurs slowly over time, by the time a farmer realises he has a problem, he has already suffered financial losses over a number of years, often placing him in a financial situation that he cannot raise the financial capital required for drainage without state assistance. The aim of the next phase is to develop the financial models that can determine the level of financial assistance required by the farmers.

APPENDIX 3. DETAILED DESCRIPTION OF THE CASE STUDY FARMS

This section starts with the procedure for selecting the case study farmers and then describes each one.

A.3.1 PROCEDURE FOR SELECTING CASE STUDY FARMERS

Main problem farmers requiring drainage were identified after consultation with OR-WUA Farmers and WUA management and University of the Free State researchers from the Department of Soil Science. A specific lower gradient farmer was apparently being water-logged by a specific up-gradient. There was currently a legal dispute whereby the up-gradient farmer is being accused of creating water-logged conditions on the farmers land down gradient of him. This case study is very similar to the situation described in Volschenk *et al.* (2005) along the Lower Orange River.

On interviewing these farmers it was found that their problem was only a water-logging problem requiring drainage and not a salinity problem. On further querying there were no farmers who would like to or who actually have installed drainage to drain salts on the OR-WUA as the Orange Riet Canal supplied good quality Orange River water. The primary reason for drainage was water-logging due to impervious layers and / or rising water tables. Under water-logging conditions drainage is essential as no crop can be grown where the soils are water-logged. It was therefore decided that instead of selecting the worst drainage problem farmers, to rather select well known / leader farmers whose financial situations are reasonably transparent to fellow farmers in the region who would like to drain some/more of their planted area particularly for long term salinisation control.

A farmer, farming near the upper boundary of the Lower Riet River sub-WUA of the OV-WUA, where the salinity levels are often highest was interviewed about salinity and drainage on his farm. He acknowledged that he gets slightly lower yields than the GWK guidelines but maintains that these don't warrant the large capital expenses of drainage – he stated that he didn't have water logged conditions and therefore didn't require drainage. He also said that leaching was a waste of irrigation water.

Another farmer, also farming near the lower boundary of the Lower Riet River sub-WUA of the OR-WUA, would have been a good case study farmer but has already installed sufficient drainage and is not currently looking at expansion. He is a prime example of a farmer irrigating with of the worst water quality in the area, but due to good soil selection and good drainage is amongst the top farmers in the area (recently selected as the top potato grower in the country). He has been able to afford the costs of drainage as he gets a higher return from his crops as he processes and adds value on the farm and markets a consumer ready product through contracts with large retailers. His situation is therefore not typical.

Regarding the selection of a CSF for the Lower Orange area (LO-Area), Mr Hannes Gerber from the Northern Cape DoA suggested we ask Mr Dirk Malan, a past VinPro (the South African wine producers association) representative for the entire Orange River, as he would have the best idea of a good worst case / representative case study farmer. As irrigation farmers are spread out along a vast distance along the Orange River, and all belong to a number of water boards and WUAs, Mr Tobie Nortje, CEO of the Boegoeberg WUA was also consulted, and he agreed that Mr Malan's opinion would be the best. Incidentally, Mr Armour was invited to a meeting of the Boegoeberg WUA with the Development Bank the following day in which the WUA was interested in applying for funding to upgrade their entire water delivery and drainage infrastructure as deterioration has caused water-logging conditions in large areas of developed land and farmers were claiming compensation.

The three commercial case study farmers therefore selected in the three areas will therefore be referred to as:

- OV-WUA CSF – Orange Vaal Case study farm / farmer
- OR-WUA CSF – Orange Riet Case study farm / farmer
- LO-Area CSF – Lower Orange Case study farm / farmer

Regarding the level of financial data the farmers were prepared to provide in the light of their names possibly being mentioned as case study farmers or depending on what they had available, the OV-WUA CSF provided sufficient data for a comprehensive financial analysis, while the OR-Area CSF only provided the basic data as requested from the basic data setup sheet that was compiled. Sufficient data was also obtained from Mr Malan and the LO-Area CSF from Keimoes, to conduct a full financial analysis for the LO-Area CSF as the case study farmer for the Lower Orange River (LO-Area CSF).

Table 7.1 is a set-up table for the farm level financial analyses containing the basic data for all the farmers to be analysed in this consultancy. The farmer selected at the bottom of Table 7.1 is the farmer selected for analysis with the model. Table 7.1 shows how the drainage costs are calculated for the selected farmer. Under Status Quo and Additional Drainage at the bottom of the table are the respective hectares to be inputted into the SMsim model as the Base Case and Scenario 3 to simulate the effect of additional drainage.

Table 7.1. The drainage setup data (ha) required for the financial model (FinStat SMsim) with the OV-WUA CSF selected.

	LO-WUA CSF	OTHER	OR-WUA CSF	OV-WUA CSF
Sub-WUA	RScm = L-Orange	RIoR	Rscm	Vall
Total irrigable land currently available	74	500	150	200
Water Rights	74	263	115	141
Additional water rights purchased	0	0	0	29
Currently drained	16	226	27	60
Un-drained with sufficient natural drainage	0	0	70	60
Additional drainage required	58	35	15	40

	OR-WUA CSF		*Select farmer for analysis*
Sub-WUA	Vall		*Can change according to water source analysed*
Total irrigable land currently available	200	**200**	Max irrigable
Water Rights	141	**30**	To leave fallow or withdraw from farming
Additional water rights purchased	29	**170**	Total water rights available
Currently drained	60	**140**	remaining artificially un-drained
Un-drained with sufficient natural drainage	60	**80**	remaining with insufficient drainage
Additional drainage required	40	**40**	still remaining with insufficient drainage
	Status Quo..	**Additional drainage**	
To plant to Base Case cropping	**50**	**10**	*can't have -ve value*
To plant to Scenario 3 cropping	**120**	**160**	*(forces drainage < water rights)*
	170	***170***	*Must be equal*
Starting year for analysis		**1**	*e.g. 1 or 2005*
Stochastic Run		**80**	*select 1 to 100*

A.3.2 OV-WUA FARMER

Although the OV-WUA CSF's farm (see Figure 7.1) is part of the OV-WUA it is situated at the bottom end of the Riet River and often receives only Lower Riet River water quality. For this analysis however the WRPM model will be used the simulate 20 years of monthly soil salinisation for ***Vall*** to be used for the OV-WUA CSF.

Figure 7.1. A Google earth view of the OV-WUA CSF

Table 7.2 differentiates between the irrigable area and actual water rights, additional water rights bought or sold and the drainage status of area irrigated.

Table 7.2. OV-WUA case study farmer land and water use and drainage status

Total irrigable land currently available	ha	**200**
Water Rights	ha	**141**
Additional water rights purchased	ha	**29**
Currently drained area	ha	**60**
Un-drained with sufficient natural drainage	ha	**60**

Table 7.3 shows the calculation of the drainage costs, repayment intervals and time required for drainage installation. The OV-WUA CSF's main reason for leaching is mainly due to water-logging and not necessarily salinisation.

Table 7.3. OV-WUA case study farmer drainage details and costs

Additional drainage required	Ha	**40**	Reason for additional drainage:
Average clay % of area to be drained	%	**20%**	***Water-logging*** ………………………
Total expected drainage cost	R/ha	**25 000**	Time required to install additional
Loan Term	yrs	**20**	drainage(weeks): **20**
Interest rate	%/yr	**15.5%**	
Payments per year	nr.	**4**	

In Table 7.4 OV-WUA CSF has indicated his current cropping composition together with the expected yields on well drained and on poorly drained soils, as well as his cropping composition changes with additionally drained soil. The OV-WUA CSF will plant 10 ha less lucerne and 5 ha more dry-beans and 5 ha more onions on the additionally drained soils. The OV-WUA CSF indicated he wouldn't plant higher value permanent crops on the land to be drained as there would be too much of a flood risk close to the river.

Table 7.4. OV-WUA case study farmer cropping compositions

	Currently planted on **well** drained soils	Currently planted on **poorly** drained soils	Will plant on **additional** drained soils	Average **yield** on well drained soils	Average **yield** on poorly drained / saline soils
Crops:	***ha***	***Ha***	***ha***	***t/ha***	***t/ha***
Barley	**0**	**0**	**0**		
Beets	**0**	**10**	**0**		
Carrots	**0**	**0**	**0**		
Cotton	**0**	**0**	**0**		
Cucurbits	**0**	**0**	**0**		
Dry_Beans	**5**	**0**	**+5**	**3**	**2**
Fruit	**0**	**0**	**0**		
Lucerne	**0**	**40**	**-10**	**25**	**18**
Maize	**90**	**0**		**14**	**10**
Olives	**0**	**0**	**0**		
Onions	**5**	**0**	**+5**	**50**	**35**
Pastures	**0**	**0**	**0**		
Peanuts	**0**	**0**	**0**		
Pecan_nuts	**0**	**0**	**0**		
Potatoes	**0**	**0**	**0**		
Soybeans	**0**	**0**	**0**		
Sunflower	**0**	**0**	**0**		
Vegetables	**0**	**0**	**0**		
Vineyards	**0**	**0**	**0**		
Wheat	**110**	**0**	**0**	**7**	**6**
Other ………..					
Other ………..					
Other ………..					

Table 7.5 is a list of the most important Balance Sheet data from the OV-WUA case study farm used for setting up the model.

Table 7.5. OV-WUA case study farmer basic Balance Sheet data for 28 Feb 2007

Current liabilities (e.g. Production loan)	R	311 000
Medium-term liabilities (2-5 year loans)	R	0
Long-term liabilities (5+year loans)	R	2 000 000
Current assets (e.g. Money in bank)	R	541 823
Medium-term assets (i.e. movable assets)	R	958 800
Fixed assets (i.e. value of farm)	R	6 437 000

Table 7.6 is a list of the most important income statement data from OV-WUA case study farm used for setting up the model.

Table 7.6. OV-WUA case study farmer basic Income statement data for 01 Mar 05 - 28 Feb 06

Gross farm income	R	1 656 386
Total directly allocatable production costs	R	1 002 811
Total fixed costs	R	318 950
Non-farm income	R	0
Income Tax	R	11 000
Private & household expenses	R	242 500

A.3.3 OR-WUA FARMER

The OR-WUA case study farm is situated very much in the middle of the Riet Irrigation Scheme (***Rscm***), and has land on both the sandy soils and heavier soils of the scheme. In Figure 7.2 one can see the road passing through his farm which roughly divides the sandy soils to the south (left) and clayey soils to the north (right).

Figure 7.2. Google earth view of OR-WUA case studies farm: OR case study farm

Table 7.7 differentiates between the irrigable area and actual water rights, additional water rights bought or sold and the drainage status of area irrigated. The negative 30 filled in for additional water rights is to show that the OR-WUA CSF rents out 30 ha of his water rights. For the 30 ha that he rents out however, he still plants the equivalent area of his full quota, but for this 30 ha he irrigates from a borehole sunken into the deep groundwater.

Table 7.7. OR-WUA case study farmer water & land use and drainage status

Total irrigable land currently available	ha	**224**	
Water Rights	ha	**170**	
Additional water rights purchased / *rented out*	ha	**-30**	*Uses groundwater, renting out excess*
Currently drained area	ha	**27**	
Un-drained with sufficient natural drainage	ha	**70**	

Table 7.8 shows the calculation of the drainage costs, repayment intervals and time required for drainage installation. The OR-WUA CSF's main reason for leaching is also mainly due to water-logging and not necessarily salinisation.

Table 7.8. OR-WUA case study farmer drainage details & costs

Additional drainage required	ha	**15**	Reason for additional drainage:
Average clay % of area to be drained	%	**10%**	***Water-logging***/*Salinity?* ………………………
Total expected drainage cost	R/ha	**16 000**	Time required to install additional
Loan Term	yrs	**0**	drainage(weeks): *In-between crops*
Interest rate	%/yr	**10%**	*Return required*
Payments per year	nr.	**n/a**	

In Table 7.9 the OR-WUA CSF has indicated his current cropping composition together with the expected yields on well drained and on poorly drained soils, as well as his cropping composition changes with additionally drained soil. The OR-WUA CSF will plant 15 ha less lucerne on his poorly drained soils and 15 ha barley on the additionally drained soils. He indicated he wouldn't plant higher value permanent vine crops on the land to be drained as the quotas for wine are full. Furthermore there is a pomegranate initiative underway that he is looking into to possibly plant on the drained land.

Table 7.9. OR-WUA case study farmer cropping compositions

	Currently planted on **well** drained soils	Currently planted on **poorly** drained soils	Will plant on **additional** drained soils	Average **yield** on well drained soils	Average **yield** on poorly drained / saline soils
Crops:	***ha***	***ha***	***Ha***	***t/ha***	***t/ha***
Barley	**30**		**15**	**7**	**6**
Beets					
Carrots					
Cotton					
Cucurbits					
Dry_Beans					
Fruit					
Lucerne	**30**	**40**	**-15**	**21**	**21**
Maize					
Olives					
Onions					
Pastures					
Peanuts					
Pecan_nuts					
Potatoes					
Soybeans					
Sunflower					
Vegetables					
Vineyards	**15**				
Wheat					
Other …………OATS	**56**			**5**	**5**
Other …………					
Other …………					

Table 7.10 is a list of the most important Balance Sheet data from the OR-WUA CSF used for setting up the model.

Table 7.10. OR-WUA case study farmer Basic Balance Sheet data for 28 Feb 2007

Current liabilities (e.g. Production loan)	R	0	*Farms debt free*
Medium-term liabilities (2-5 year loans)	R	60 000	*Bakkie on hire purchase*
Long-term liabilities (5+year loans)	R	700 000	*Outstanding on new land*
Current assets (e.g. Money in bank)	R	} 13 000 000	
Medium-term assets (i.e. movable assets)	R		
Fixed assets (i.e. value of farm)	R		

Table 7.11 is a list of the basic income statement data from the OR-WUA CSF required for setting up the model.

Table 7.11. OR-WUA case study farmer Basic Income statement data for 01 Mar 05 - 28 Feb 06

Expected gross farm income	R	6 384 375	
Total directly allocatable production costs	R	204 600	
Total fixed costs	R	480 000	
Non-farm income	R	24 000	*Rental of water rights*
Income Tax	R	*Plan to farm at a loss but partners pay tax on salaries earned*	
Private & household expenses	R	420 000	

A.3.4 LO-AREA CASE STUDY FARM,

With 35 000 ha irrigated between Boegoeberg and Onseepkans (Volschenk *et al.* 2005:3), returnflows accounting for 30% of water in the water balance (Volschenk *et al.* 2005:4) and a high salt generation potential of the soil, a lot of salts coming from surrounding soils and a large percentage of irrigation returnflows will reach the LO-CSF. Irrigation water salinity currently fluctuates around 500mg/l (77mS/m) but does on occasion reach 750mg/l (115 mS/m) (Volschenk *et al.* 2005:4). In Volschenk *et al.* 2005:4, it is further predicted that river salinity will increase by 25% by 2030 at Boegoeberg and Kakamas (just downstream of the CSF). This is not a very good outlook for the LO-case study farmer who already has clear evidence of salinisation on his farm. With irrigation quotas of between 15000 and 18000 mm per ha and very high evaporation, even the small concentrations of salts present in the generally good quality Orange River water can rapidly build up in irrigated soils in the area. Where shallow saline water-tables occur this obviously exacerbates the situation.

The LO-CSF is situated in the Friarsdale Irrigation Scheme, near the end of the earth canal that passes through his farm (this possibly also contributing to rising water tables). Predominantly old vines are flood irrigated with lower value cotton and lucerne crops planted on land where unproductive vineyards have been taken out, but not re-established due to a lack of funds to install the essential accompanying drainage system. In Figure 7.3 the boundaries of the LO-CSF's farm are indicated and from a 2.83km altitude, the patchy growth is evident in his vineyards with white patches showing in places.

Figure 7.3. Google earth view of the LO-CSF

In Volschenk *et al.* 2005, an EC of 9.9 dS/m, by far the highest concentration salts in returnflows was measured at SMB Boerdery situated just up-gradient to the LO-CSF, within the drainage basin from SMB Boerdery clearly visible in Figure 7.4. This relates to a very high TDS of 6435 mg/l. Also evident from their results is that a considerably higher level of nitrates (NO_3-N) also occurs in the drainage from SMB amounting to 34.3 mg/l (Volschenk *et al.* 2005:32). This could indicate high levels of nitrates applied through fertilizers leaching from neighbouring lands and accumulating to such high levels. SMB is the only sampling point by Volschenk *et al.* 2005 with the predominant soil type being wind blown sand, thus another possibility is that this sand is laden with salts and nitrates accumulated from the surfaces of the places from which it has blown over time.

In Volschenk *et al.* 2005:54 it states that the tendency for EC in the less saline soils to more than double over the 30 day equilibration period suggests an important contribution to salinity from the dissolution of sparingly soluble minerals. Furthermore the trend is for increasing salinity in vineyard soils when compared to adjacent virgin soils.

Volschenk *et al.* 2005:59 suggests that evaporation is the main cause of the acutely saline drainage returnflows from SMB.

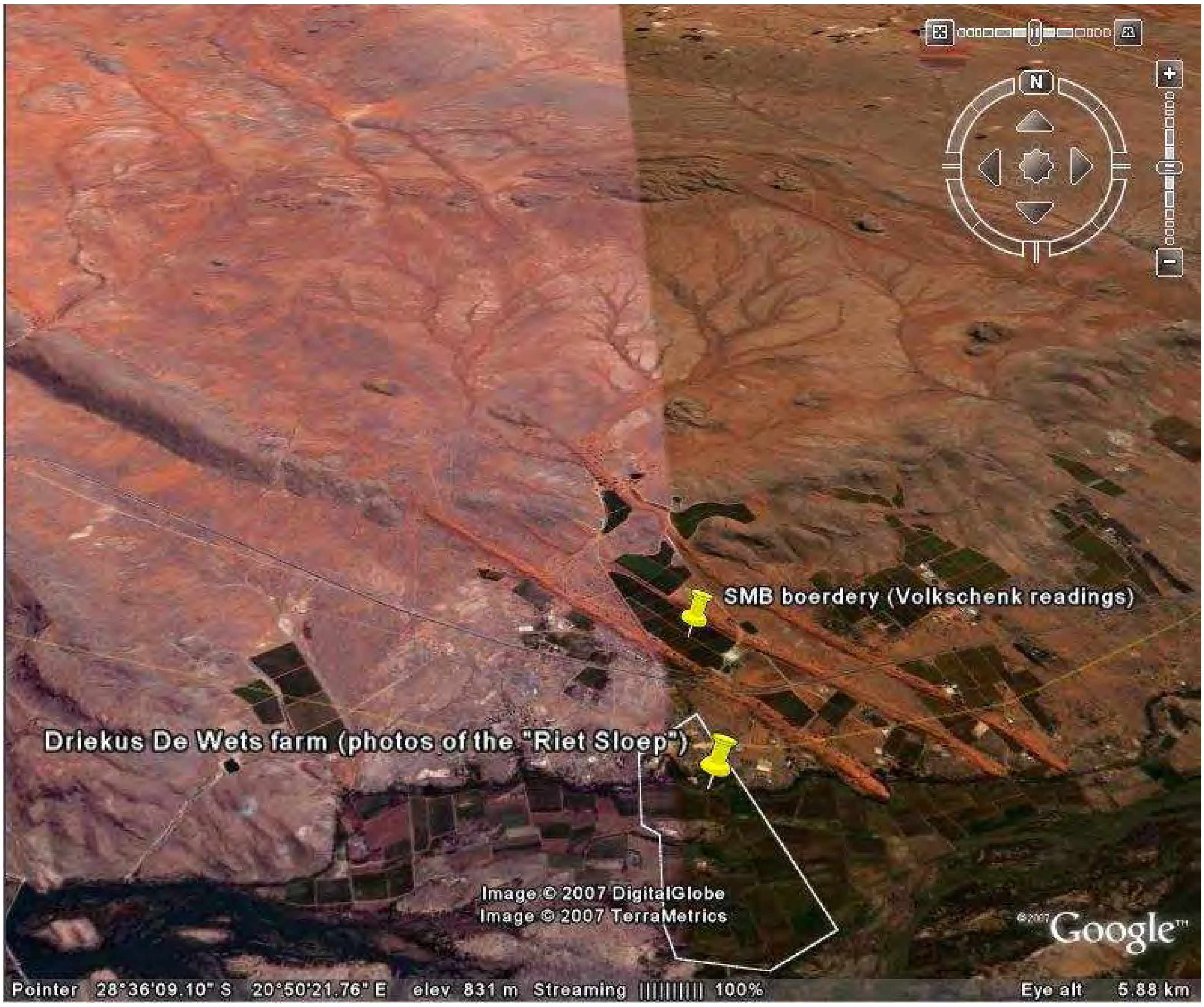

Figure 7.4. A Google Earth tilted camera angle view of the the LO-CSF in relation to the work done by Volschenk *et al.* (2005) at SMB Boerdery and the very prominent drainage basin up-gradient.

Table 7.12 differentiates between the irrigable area and actual water rights, additional water rights bought or sold and the drainage status of area irrigated.

Table 7.12. LO-AREA case study farmer water & land use and drainage status

Total irrigable land currently available	ha	**74**	
Water Rights	ha	**74**	*canal system 15 000 mm x 74 ha*
Additional water rights purchased	ha		
Currently drained area	ha	**16**	*all flood irrigation*
Un-drained with sufficient natural drainage	ha	**0**	*Last delivery point in canal thus don't always get enough water*

25 ha of the LO-CSF are "riet sloepe" (water-logged reed beds / depressions) of which only 6ha can be potentially reclaimed.

Table 7.13 shows the calculation of the drainage costs, repayment intervals and time required for drainage installation. The LO-CSF main reason for leaching is due to water-logging, but signs of salinisation are clearly evident. To cope with the water-logging in the past they raised their lands creating depression from where they took the soil. These depressions have become overgrown with reeds which the LO-case study farmer hoped he could graze with dairy cattle, but he has not been as successful as he expected. The high cost of drainage is not so much the due to the clay percentage of the soils, but due to the layering of the soils with impervious layers that first need to be broken before the drainage can be installed.

Table 7.13. LO-AREA case study farmer drainage details & costs

Additional drainage required	ha	58	Reason for additional drainage:
Average clay % of area to be drained	%	20%	***Water-logging*** ………………………
Total expected drainage cost	R/ha	28 000	Time required to install additional
Loan Term	yrs	20	drainage(weeks): *When vines are replanted*
Interest rate	%/yr	15.5%	*Return required*
Payments per year	nr.	4	

In Table 7.14 the LO-case study farmer has indicated his current cropping composition together with the expected yields on well drained and on poorly drained soils, as well as his cropping composition changes with additionally drained soil. the LO-case study farmer will plant 3 ha less lucerne and 8 ha less cotton on his poorly drained soils and 58 ha vines on the additionally drained soils. Of the current 63 ha planted to vines only 6 ha are wine grapes, and the rest are used for raisins. 34% of the vineyards are 8-15 years old while the rest (66%) are all 20 years or older, having reached the end of their productive lifespan, hence the large amount of hectares that need to be drained. The LO-case study farmer had been constrained by capital to re-establish the vineyards because to do so without sufficient drainage would be a waste of money, but the costs of the additional drains have been the main constraint. Where vineyards are unproductive (direct returns don't exceed direct costs) they have been pulled up and cotton and lucerne planted.

Table 7.14. LO-AREA case study farmer cropping compositions

	Currently planted on **well** drained soils	Currently planted on **poorly** drained soils	Will plant on **additional** drained soils	Average **yield** on well drained soils	Average **yield** on poorly drained / saline soils
Crops:	***Ha***	***ha***	***Ha***	***t/ha***	***t/ha***
Barley					
Beets					
Carrots					
Cotton		**8**	**-8**	**4**	**7**
Cucurbits					
Dry_Beans					
Fruit					
Lucerne		**3**	**-3**	**16**	**23**
Maize					
Olives					
Onions					
Pastures					
Peanuts					
Pecan_nuts					
Potatoes					
Soybeans					
Sunflower					
Vegetables					
Vineyards	**16**	**47**	**58**	**10**	**20**
Wheat					
Other …………					
Other …………					
Other …………					

Table 7.15 is a list of the most important Balance Sheet data from the LO-case study farmer used for setting up the model.

Table 7.15. LO-AREA case study farmer Basic Balance Sheet data for 28 Feb 2007

Current liabilities (e.g. Production loan)	R	500 000
Medium-term liabilities (2-5 year loans)	R	840 000
Long-term liabilities (5+ year loans)	R	1 900 000
Current assets (e.g. Money in bank, Co-op shares, etc.)	R	150 000
Medium-term assets (i.e. movable assets)	R	823 050
Fixed assets (i.e. value of farm)	R	6 560 550

Table 7.16 is a list of the basic income statement data from the LO-case study farm required for setting up the model.

Table 7.16. LO-AREA case study farmer Basic Income Statement data for 01 Mar 05 - 28 Feb 06

Expected gross farm income	R	1 600 000	
Total directly allocatable production costs	R	400 000	
Total fixed costs	R	425 000	
Non-farm income	R	0	*Wife's income*
Income Tax	R	*0*	*Manages tax that minimal gets paid*
Private & household expenses	R	0	*Live on wife's income*

Table 7.15 and Table 7.16 are the LO-CSF's guestimates. More accurate values are compiled from the financial statements supplied by the LO-CSF, and these are used in the model.

APPENDIX 4. ORANGE-VAAL CASE STUDY FARM RESULTS

This section lists the farm level drainage feasibility analysis model results for the OV-WUA case study farm under the following main headings; Direct profitability -, Bank repayment Ability -, Financial analysis - and Stochastic analysis model results, ending off with and Economic interpretation of the results.

A.4.1 DIRECT PROFITABILITY MODEL RESULTS

Drainage costs are calculated in Table 7.17 for the OV-WUA case study farm's proposed additional drainage. The 40 hectares required to drain at a cost of R28 571 per ha will cost a total of R1 142 857 which the OV-WUA case study farmer will have to repay at a quarterly rate of R34 318.

Table 7.17. Drainage costs for the OV-WUA case study farm

		OV-WUA case study farm
Hectares to drain	Ha	**40**
Average clay %	%	25%
Drainage Cost	/ha	**R 28 571**
Grant	%	0%
Value of grant	/ha	R 0
Total loan	/farm	**R 1 142 857**
Loan Term	years	20
Interest rate *(Subsidised)*	%	10.50%
Payments /year	terms	4
Repayments	/term	**R 34 318**
Hectares irrigable	Ha	200
Percentage to drain	%	20%
Increase in value of land	/ha	R 4 000
Increase in value of land	/farm	**R 160 000**

Table 7.18 is the simple rate of return calculated for the main crops and cropping combinations planted on the OV-WUA case study farm, with vineyards added as a potential long term crop for comparison. The simple rate of return for additional yields from the combination of crops when including drainage is 8.04% amounting to increased returns of R 2 295 per hectare. When however accounting for the costs of the drainage installation (i.e. R3 471 / ha per year for 20 years) none of the crops individually or wheat and maize combined in rotation produce a positive direct profitability of increased earnings, indicating that although drainage increases the rate of return, the increased profits do not cover the costs of the drainage investment.

When looking at the direct profitability of GMASC after draining only wheat's GMASC on its own doesn't cover the cost of the drainage as wheat is a salt tolerant crop not befitted by drainage at the modelled level of ECe (mS/m). However when combined with maize in rotation, the two crops GMASCs deliver a ROR of 8.73%, higher than that of lucerne and vineyards.

The first column of values from the left in the bottom six rows (in the "Units" column) are the combined values for wheat and maize in rotation and these are planted as 2 crops in one year.

The reason for calculating the ROR on increased earnings less drainage costs is to evaluate whether a farmer will at least be at the same level of immediate welfare with drainage to pay off versus carrying on without drainage. All results in Table 7.18 show that the increased GM returns from drainage are not sufficient to cover the costs of drainage.

At the bottom of the table are the breakeven loan repayments that the farmer can afford to maintain at the same level of returns for each crop and cropping combination as without drainage. This is then re-calculated as the maximum loan amount that the farmer can afford for drainage per hectare. Subtracting this amount from the actual costs of drainage, leaves the amount of grant required for the farmer to breakeven. Results show that it is infeasible to drain wheat alone, but that a wheat and maize in rotation is feasible. The most feasible crop to drain on a per hectare basis for the OV-WUA case study farm would be vineyards, followed by maize alone, a wheat-maize rotation, lucerne and the least feasible being draining wheat alone. In reality, the OV-WUA case study farmer cannot plant vineyards in the land earmarked for drainage as there is too high a risk of flooding.

Table 7.18. The calculation of the simple rate of return (ROR) for the OV-WUA CSF

	R = Simple rate of return = (I – D) / O	**Unit**	**8.03%**				
	I = Average Annual After tax (increased) earnings	R/ha	R 2 295	*GMASC level, fixed costs and tax not included as /ha*			
	D = Annual Average depreciation of investment	R/ha	R 0	*Lasts a lifetime if properly maintained*			
	O = Capital Outlay Required	R/ha	R 28 571	*Subtract from taxable income*			
	Interest rate	*%/yr*	10.5%				
	Term	*Yr*	20				
a	Capital repayment costs	R/ha/yr	R 3 471				
	Additional maintenance costs	R/ha	R 286	*1% of capital cost per year*			
	Water & Electricity costs	R/mm/ha	0.68	0.49	**10%**	***Chose crop***	
	Crops to be planted on drained soils		**Maize**	**Wheat**	**Lucerne**	**Vineyards**	
	Pre-drain Yield	ton/ha	**11.0**	**6.0**	**18.0**	**18.0**	
	After-drain Yield (Max yield)	ton/ha	14.0	7.0	20.4	20.4	
	Crop Water Use	mm/ha	749	601	1156	625	
	Leaching required to achieve max yield	%	**10%**	**5%**	**10%**	**5%**	
	Crop Price (R/ton)	R/ton	R 832	R 1 208	R 552	R 725	
	Pre-drain Gross income	R/ha	R 9 154	R 7 246	R 9 931	R 13 050	
	After-drain Gross income	R/ha	R 11 651	R 8 454	R 11 255	R 14 778	
	Pre-drain Production costs - ex harvest (R/ha)	R/ha	R 5 813	R 5 386	R 3 997	R 8 429	
	Harvesting costs (R/ton)	R/ton	R 96	R 103	R 44	R 18	
	Pre-drain Production costs - inc. harvest (R/ha)	R/ha	R 6 865	R 6 005	R 4 791	R 8 753	
	After-drain Production costs (R/ha)	R/ha	R 7 438	R 6 415	R 5 261	R 9 103	**TOTAL**
	% area planted per year	%	**80%**	**70%**	**15%**	**5%**	**170%**
b	Gross Margin above specified costs pre drain		R 2 289	R 1 241	R 5 141	R 4 297	**R 3 685**
c	Gross Margin above specified costs after drain	**Wht+Mz**	R 4 212	R 2 039	R 5 995	R 5 675	**R 5 980**
a-c	Direct profitability of GMASC after drain	*2 494*	589	-1 565	2 238	1 918	**2 237**
	ROR on GMASC after drainage	*8.73%*	2.06%	-5.48%	7.83%	6.71%	**7.83%**
c-b	I = Increased earnings (change in margin)	*2 722*	1 924	798	854	1 378	**2 295**
	ROR of increased earnings	*9.53%*	6.73%	2.79%	2.99%	4.82%	**8.03%**
I-a	Direct profitability of increased earnings	*-749*	-1 548	-2 673	-2 617	-2 093	**-1 176**
	ROR of increased earnings less drainage costs	*-2.62%*	-5.42%	-9.36%	-9.16%	-7.32%	**-4.12%**
	Breakeven Repayments	*R 1 635*	R 1 941	R -306	R 770	R 2 460	R 1 577
	Maximum drainage loan affordable	*R 13 460*	R 15 979	R -2 519	R 6 338	R 20 248	R 12 983
	Grant as % of total drainage costs	53%	44%	109%	78%	29%	55%
	Grant per ha required	***R 15 111***	**R 12 592**	**R 31 091**	**R 22 234**	**R 8 323**	**R 15 588**

To financially justify drainage on this farm, the second last row shows that a subsidy of 55% would be required.

The SMCEB model calculates for each crop a gross margin (GM) and 20 year cash flow. For a starting ECe value of 300 mS/m Table 7.19 list the crop level GM and ranks the crops in terms of direct profitability with and without drainage.

Table 7.19. A crop level GM comparison for the OV-WUA CSF with ECe = 300

	GM with leaching	Rank	GM without leaching	Rank	Change	Rank
Barley	1 498	20	1 533	20	-35	15
Beets	6 932	9	6 955	7	-23	11
Carrots	10 807	7	3 243	13	7 564	3
Cotton	3 387	14	3 431	12	-44	19
Cucurbits	19 402	4	17 677	3	1 725	7
Dry Beans	3 026	15	1 853	19	1 172	9
Fruit	41 538	2	26 069	2	15 469	2
Lucerne	6 291	10	5 603	9	689	10
Maize	4 454	13	2 890	14	1 565	8
Olives	9 282	8	9 314	6	-32	13
Onions	54 142	1	35 243	1	18 899	1
Pastures	2 109	19	2 157	18	-48	20
Peanuts	2 422	16	2 457	15	-35	14
Pecan nuts	22 945	3	15 564	4	7 381	4
Potatoes	12 423	5	5 123	10	7 300	5
Soybeans	6 196	11	6 233	8	-37	18
Sunflower	2 395	17	2 419	16	-24	12
Vegetables	11 634	6	11 669	5	-35	17
Vineyards	5 946	12	3 907	11	2 039	6
Wheat	2 310	18	2 345	17	-35	16

Crops for which drainage will pay for itself (i.e. directly profitable) are all the crops that have a change greater than the drainage repayment costs (i.e. R3 248), namely Onions, Fruit, Carrots, Pecan nuts and Potatoes in order of profitability. It must however be noted that the additional costs of establishing the long term crops and changing irrigation systems would still have to be calculated.

Table 7.20 gives the price and yield sensitivity of Maize GM and Table 7.21 the impact of increased leaching fractions on yield and GM. Price, yield and leaching fraction sensitivity analyses are done for all the crops in the model which is set up for farmer operation.

Table 7.20. An example of the price:yield sensitivity analysis for maize

Maize	GMASC-Drainage				Breakeven Yield	
R *ton*	11.0	12.0	13.0	14	*BE**	*BE+D***
600	R -4 593	R -4 084	R -3 576	R -3 068	*12.53*	*20.08*
900	R -1 300	R -489	R 322	R 1 132	*7.86*	*12.59*
1200	R 1 993	R 3 106	R 4 219	R 5 332	*5.72*	*9.17*
1500	R 5 286	R 6 701	R 8 117	R 9 532	*4.50*	*7.21*
1800	R 8 579	R 10 296	R 12 014	R 13 732	*3.71*	*5.94*
2100	R 11 871	R 13 892	R 15 912	R 17 932	*3.15*	*5.05*
*BE+D***	*R 1 018*	*R 941*	*R 875*	*R 819*		

* BE is the breakeven yield of the Status Quo at different crop prices

** BE+D is the breakeven crop price at different yields or the breakeven yield at different prices of the additional (+D) drainage scenario.

Linked to ROR is a sensitivity analysis of price versus yield with additional drainage as well as the breakeven yields of various prices (last two columns) with and without accounting for the costs of the drainage and breakeven prices for various yields is presented in bottom row. Table 7.20 is only a sensitivity analysis of

Maize, but in the model a sensitivity analysis table is set up for each of the crops shown in Table 7.18. Note that Table 7.20 is a sensitivity analysis for GMASC level only. Results indicate that maize alone at a price above R1 018 for yields above 11 ton per hectare can on a GMASC basis profitably cover the costs of drainage. But at the 10 year average real maize price (2005 basis year) of R 832 near maximum yields are required (13.26 t/ha) to just breakeven on a GMASC basis with a maize crop alone.

Table 7.21. The effect of leaching on drainage profitability

		MAIZE	Price	R 832	R 832		
Leaching fraction		0%	5%	10%	15%	20%	30%
ECe Threshold	mS/m	170	204	238	272	306	374
ECe Gradient	%/mS/m	0.120	0.120	0.120	0.120	0.120	0.120
Weighted ave. ECe (mS/m)	350	*2275*	*mg/l*				
Max Physiological yield	ton/ha	**14.00**	14.00	14.00	14.00	14.00	14.00
% of max Physiological yield	**%**	**78**	82	87	91	95	100
Modeled yield	**ton/ha**	**10.98**	**11.55**	**12.12**	**12.69**	**13.26**	**14.00**
% improvement due to leaching			5.20%	10.41%	15.61%	20.82%	27.55%
Crop water requirement	mm/ha	749	787	824	862	899	974
Increase in Gross Income from leaching	***2516.51***	0.00	475.34	950.68	1 426.03	1 901.37	2 516.51
Increase in Production costs	***1.17***	0.00	43.70	87.40	131.09	174.79	262.19
Increase in harvesting costs	***95.71***	0.00	54.67	109.34	164.01	218.68	289.43
Change in Gross Margin		0.00	376.97	753.95	1 130.92	1 507.89	1 964.89
GM change - Drainage costs	R/ha	-3 471	-3 094	-2 717	-2 340	-1 963	-1 506
GM change - Drainage costs (Maize Price R2 000 / ton)	R/ha	-3 471	-2 427	-1 383	-339	705	2 025

Table 7.21 is included to display the effect of leaching on drainage profitability. Here again at the 10 year real average price (2005 basis) is drainage unprofitable at all levels of leaching from 0% to 30%. Leaching more than 30% is impractical due to the delivery capacity of most irrigation systems. However at a maize price of R2 000 per ton a leaching fraction of 20% yields positive results.

A.4.2 BANK REPAYMENT ABILITY MODEL RESULTS

The bank repayment ability model, BankMod, as set up for the OV-WUA case study farm produced the results shown in Table 7.22.

Table 7.22. The Bank repayment ability cash flow model analysis results for the OV-WUA case study farm of the Status Quo (SQ) situation versus the Additional drainage (+D) scenario

	Status Quo (SQ)	Additional drainage (+D)		SQ	+D
MIN Cash Flow	*-577 230*	*-612 322*	*Net Present Value (NPV)*	*1 399 287*	*1 400 915*
MAX Cash Flow	*5 756 435*	*5 877 828*	*Internal Rate of Return (IRR)*	*11%*	*8.88%*

Interest rates				Annual capital cost replacement			R 120 000		
+ve		1%		Total value of intermediate / loose assets			R 13 000		
-ve		15%					Annual discount rate		16%
	YEAR 1	YEAR 1	YEAR 1	STARTING	YEAR 1	10%	Monthly discount rate		1.33%
	Income Streams	*Less: Direct Costs*	*Less: Overheads / Indirect Costs*	*Cash Flow*	*Bank Interest*	*Less: depreciation on loose assets*	*Value of movable assets*	*= Surplus before tax*	*NPV*
SQ	*2 118 919*	*-1 607 751*	*-216 000*	*-300 000*	*-59 448*	*-11 465*	*121 791*	*290 010*	*1 399 287*
+D	*2 256 852*	*-1 618 965*	*-335 665*	**-300 000**	*-64 236*	*-11 465*	***121 791***	***296 876***	***1 400 915***

The Net Present Value (NPV) of the surpluses over 20 years equals the amount of Capital Debt that the farmer can repay, thus the farmers Repayment Ability. The Repayment Ability for the OV-WUA case study farm is therefore R1 400 915. This is the maximum amount of debt that the bank will allow the OV-WUA case study farm. As the OV-WUA case study farm already loans R300 000 (Starting cash flow value in Table 7.22) for production inputs from the bank and GWK, he will only be allowed to loan up to R1 100 915 to install drainage. This is just short of the R 1 142 857 calculated to drain the required 40 hectares at R 28 571 (see Table 7.17).

With drainage, the OV-WUA case study farmer's maximum cash flow value is R612 322, so he will therefore have to make provision for an additional R312 322 overdraft at the appropriate time over and above the R300 000 he has already made provision for.

A.4.3 FINANCIAL ANALYSIS RESULTS

In this section, the results for the OV-WUA case study farm of the two versions of the financial analysis model are discussed;

- the CEB based model, SMCEBs, in which self simulated soil salinisation values / sequences / trends are inputted, reports results as NPV, IRR and B:C ratios for different levels of farm financial analysis (GM, NFP and FP levels), and
- the financial analysis model, FinAnalysis, reports balance sheet, income statement and cash-flow results for the OV-WUA case study farmer.

A.4.3.1 SMCEBs model results for the OV-WUA case study farm

The reason for including the SMCEBs model is to have a financial analysis model for which you can simulate your own progression of ECe over 20 years. Figure 7.5 is a theoretical simulation of ECe if the OV-WUA case study farm doesn't drain (the NO drainage line where ECe progressively gets worse), versus the theoretical improvement with drainage (the WITH drainage line where ECe improves dramatically in the first few years as salts get leached out, and then flattens out to equilibrium conditions with the irrigation water salinity)

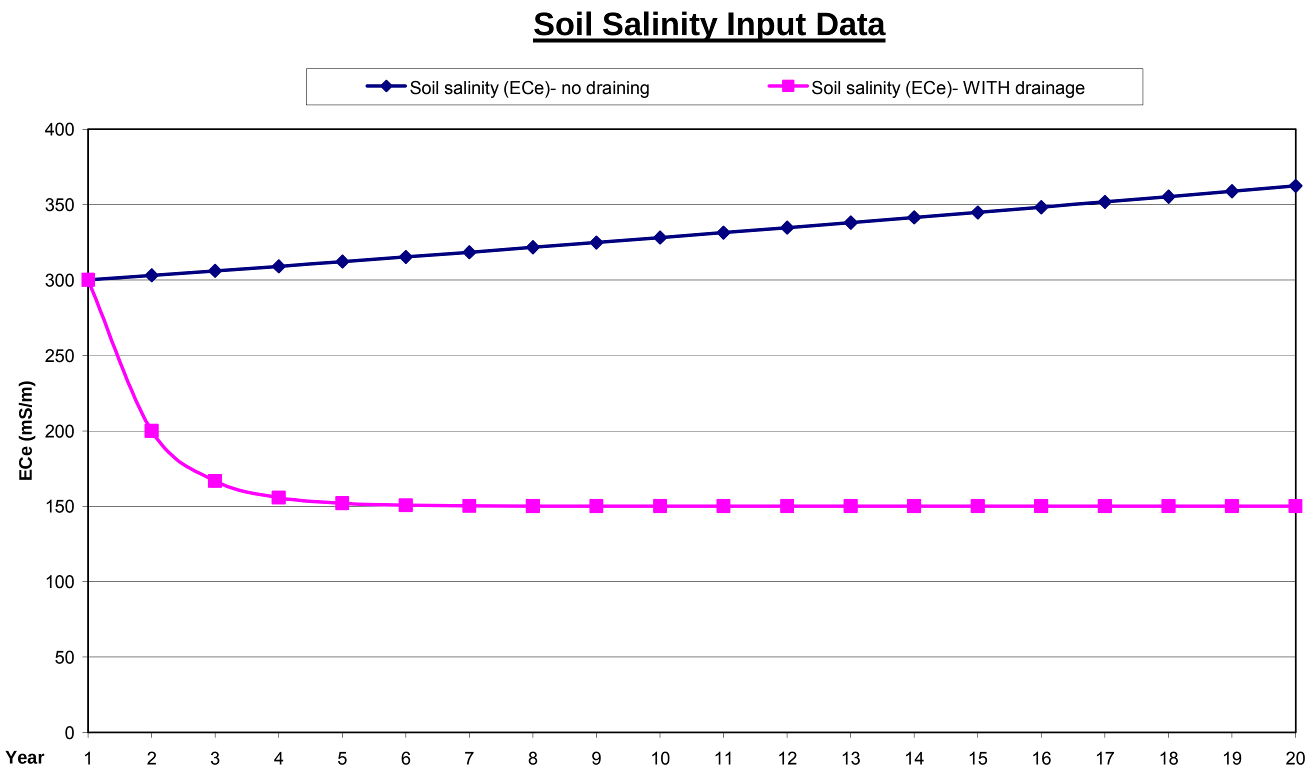

Figure 7.5. Simulated ECe data for 20 years for input into the SMCEBs model

The other reason for the SMCEBs model is to further the direct profitability models to whole farm level, as well as to expand the level of financial analysis from gross margin (GM) level to include fixed costs and calculate the net farm income (NFI) and also to bring in capital costs to calculate the Farm Profit (FP); and tax provision and household expenses to calculate Net worth (NW) as appear in Table 7.23.

Table 7.23. The SMCEBs cash flow model results (R/ farm) for the OV-WUA case study farm

			R / farm
Total Income	no drains		445 036
	with drains		525 378
Total Variable Costs	no drains		279 351
	with drains		296 239
Gross Margin	no drains	GM	165 684
	with drains	GM+	229 139
Fixed Costs	no drains		40 000
	with drains		40 000
Net Farm Income	no drains	NFI	125 684
	with drains	NFI+	189 139
Capital redemption			
Remuneration to hired			0
Rentals			0
Interest on Capital	no drains		0
	with drains		150 000
Farm Profit	no drains	FP	125 684
	with drains	FP+	39 139
+Non farm income			0.00
- Capital loss			0.00
- Income tax provision			199 052
- Private & household expenses			144 000
Net Worth	no drains	NW	-217 367
	with drains	NW+	-303 912

The analysis of the results of Table 7.23 in Table 7.24 take the financial analysis further, form NFI level to Farm Profit (FP) level where the interest component of additional drainage is also subtracted.

Table 7.24 The SMCEBs cash flow model analysis results (R/farm) for the OV-WUA case study farm

			NPV	B:C ratio (:1)	*IRR*
GM Cash Flow	no drains	**GM**			*n/a*
	with drains	**GM+**			*75%*
	Difference	***GM+ - GM***			*11%*
no drains	**GM**	0%	13 051	1.46	
		12%	5 016 938	1.47	***End value***
		17%	3 811 781	1.48	**13 051 647**
With drains	**GM+**	0%	16 301	1.56	**16 301 619**
		12%	4 954 399	1.46	***3 249 972***
		17%	3 337 142	1.42	
			NPV	**B:C ratio (:1)**	***IRR***
NFI Cash Flow	no drains	**NFI**			*n/a*
	with drains	**NFI+**			*69%*
	Difference				
no drains	**NFI**	0%	12 251	1.42	
		12%	4 718 160	1.43	***End value***
		17%	3 586 670	1.44	**12 251 647**
With drains	**NFI+**	0%	15 501	1.52	**15 501 619**
		12%	4 655 621	1.42	***3 249 972***
		17%	3 112 031	1.38	
			NPV	**B:C ratio (:1)**	***IRR***
FP Cash Flow	no drains	**FP**			*n/a*
	with drains	**FP+**			*51%*
	Difference				*1%*
no drains	**FP**	0%	12 251	1.42	
		12%	4 718 160	1.43	***End value***
		17%	3 586 670	1.44	**12 251 647**
With drains	**FP+**	0%	12 501	1.38	**12 501 619**
		12%	3 535 204	1.29	***249 972***
		17%	2 267 866	1.25	

A.4.3.2 Financial analysis model results

With the financial analysis data collected for the OV-WUA case study farm, the income statement, balance sheet and cash flows are compiled. Based on drainage requirements and costs the loan repayment schedule divided up into the interest and capital components is given for the OV-WUA case study farmer's additional 40 ha at R28 571 per hectare in Table 7.25. The annual repayment at a 10.5% interest rate for the loan is R138 849, of which the average capital repayment (principal) is R57 143 per year and the average interest repayment (cost of capital) is R79 778 per year. These average values are used in the balance sheet and income statements while the actual repayment schedule is used in the long term cash flow statements.

Table 7.25. The loan repayment sequence (R) for the OV-WUA case study farm, divided up into capital and interest components

Total Loan	**1 142 857**			Hectares to drain (ha)	40
Deposit	**0**		**GRANT / Farmers contribution**	Average clay (%)	25%
Principal	**1 142 857**	**/ year**	**/ month**	Drainage Cost (R/ha)	R 28 571
Interest	**10.50%**	2.63%	0.88%	Value of grant (R/ha)	0

Years	**20**	80	240
Payments/yr	1	**4**	12
Payment	138 849	34 318	11 410

Mnth	***Still owe***	***Interest***	***Capital***	***Total cost***	***Compounded monthly (12 payments per year)***		
Totals		***1 595 556***	***1 142 857***	***2 738 413***	***Year***	***Interest***	***Capital***
1	1 142 857	10 000	1 410		1	119 161	17 759
2	1 141 447	9 988	1 422		2	117 204	19 716
3	1 140 025	9 975	1 435		3	115 032	21 889
4	1 138 590	9 963	1 447		4	112 619	24 301
5	1 137 142	9 950	1 460		5	109 941	26 979
6	1 135 682	9 937	1 473		6	106 968	29 953
7	1 134 210	9 924	1 486		7	103 667	33 254
8	1 132 724	9 911	1 499		8	100 002	36 918
9	1 131 225	9 898	1 512		9	95 934	40 987
10	1 129 713	9 885	1 525		10	` 91 417	45 504
11	1 128 188	9 872	1 538		11	86 402	50 518
12	1 126 650	9 858	1 552		12	80 835	56 086
13	1 125 098	9 845	1 565		13	74 654	62 266
14	1 123 532	9 831	1 579		14	67 792	69 128
15	1 121 953	9 817	1 593		15	60 174	76 747
16	1 120 360	9 803	1 607		16	51 716	85 204
17	1 118 753	9 789	1 621		17	42 326	94 594
18	1 117 133	9 775	1 635		18	31 902	105 019
…	…	…	…		19	20 328	116 592
238	33 640	294	11 116		20	7 480	129 441
239	22 524	197	11 213		TOTAL	**1 595 556**	**1 142 857**
240	11 311	99	11 311		AVERAGE	**79 778**	**57 143**

The balance sheet for OV case study farm in Table 7.26 comparing the farm business with and without drainage is only slightly changed by the addition of the drainage loan to the long term liabilities with a subsequent increase in the current liabilities loan repayments. On the assets side the value of fixed improvements are not increased by the full cost of the drainage, but only by a mere R4 000/ha. Growth in net worth is only R117 952 with drains.

Table 7.26. Balance sheet (R/farm) for the OV-WUA case study farm

Balance sheet for	OV-WUA case study farm				28-Feb-07
LIABILITIES	*Without Drainage*	*With Drainage*	ASSETS	*Without Drainage*	*With Drainage*
Current Liabilities			Current assets		
Banks	300 000	300 000	Cash on hand / in bank	0	0
Cooperatives	900 000	900 000	Debtors	0	
Creditors	0	0	Prepaid expenses	0	0
Income tax	11 000	11 000	Life insurance	33 333	33 333
Bills payable	0	0	Negotiable securities	0	0
Current portion of long tern liabilities	0	0	Stock:	0	0
Term loans	41 764	41 764	*Crops and crop products*	0	0
Instalments payment	0	0	*Fruit products*	0	0
Lease instalments	0	0	*Production inputs*	0	0
Bond repayments	0	0	*Marketable livestock*	18 800	18 800
Long-term loans	242 986	381 836	Other	0	0
Other loans	0	0	Short-term investment	0	0
Other	0	0	*Rotating fund*	400 000	400 000
	0	0	*Co-op Shares*	200	200
Total current liabilities	1 495 751	1 634 600	Total current assets	452 333	452 333

Medium-term liabilities			Medium-term assets		
Term loans	100 000	100 000	Breeding stock	42 500	42 500
Instalment sale credit	0	0	Vehicles, mach. & equipment	892 500	892 500
Leases	40 000	40 000	Other: Office furniture	0	0
Other	0	0	Other	0	0
Total medium-term liabilities	140 000	140 000	Total medium-term assets	935 000	935 000
Long term liabilities			Fixed assets		
Bonds	0	0	Fixed improvements	1 270 000	1 270 000
Long-term loans	2 000 000	2 000 000	Land	5 167 000	5 167 000
Other	0	0	Other	0	0
Drainage loan	0	1 142 857	Increase in drained land value	0	160 000
	0	0		0	0
Total long-term liabilities	2 000 000	3 142 857	Total Fixed assets	6 437 000	6 597 000
Total Liabilities	3 635 751	4 917 457			
Net worth (from income statement)	323 215	441 167			
Total Liabilities + Net Worth	3 312 536	4 476 290	Total Assets	7 824 333	7 984 333
			Value of hired land	0	0
Growth in net worth with drains	117 952		Total capital employed	7 824 333	7 984 333
Compiled by R.J. Armour, WRC Drainage Consultancy Project			Adapted from Finance & Farmers, Standard Bank (2005)		

Looking at the income statement in Table 7.27, total sales (and also GPV) is only increased by R37 075 by installing drainage, just more than enough to only pay one quarters repayments for the drainage loan (see Table 7.17). Total production costs only increase by just under R3 000 due to additional water and electricity costs for leaching, relating to a change in Net farm Income (NFI) of just over R34 000. Adding the interest costs to NFI the gap between the *status quo* (SQ) and AD (additional drainage) is increased to a change in Net Farm Profit (NFP) of just over R52 000. The capital appreciation of the value of the farm brought about by the drainage inverts the gap between SQ and AD so that with additional drainage the farm Growth Net Worth (NW) is just over R107 000.

Table 7.27. Income statement (R/farm) for the OV-WUA case study farm

Income statement for the period		May 2005- April 2006	OV-WUA case study farm			
Description		Livestock	Crops		TOTAL	
			Without	*With*	*Without*	*With*
		Constant	*Drainage*	*Drainage*	*Drainage*	*Drainage*
Sales	Cash	20 000	3 186 455	3 223 530	3 206 455	3 243 530
	Credit	0	0	0	0	0
	Account	0	0	0	0	0
	Transport and contract work	0	0	0	0	0
	Other	0	0	0	0	0
TOTAL Sales		20 000	3 186 455	3 223 530	3 206 455	3 243 530
Consumption	Household	5 800	0	0	5 800	5 800
	Labour	3 900	0	0	3 900	3 900
	Internal		0	0	0	0
TOTAL consumption		9 700	0	0	9 700	9 700
Stock adjustment						
	Closing stock	61 300	0	0	61 300	61 300
Less:	Opening stock	61 300	0	0	61 300	61 300
Less:	Purchases	0	0	0	0	0
TOTAL stock adjustment		0	0	0	0	0

TOTAL GROSS PRODUCTION VALUE	(GPV)	29 700	3 186 455	3 223 530	3 216 155	3 253 230
Less: Production, marketing and administration costs						
Production inputs	Seed	0	241 453	241 453	241 453	241 453
	Fertiliser	0	528 886	528 886	528 886	528 886
	Herbicides	0	48 203	48 203	48 203	48 203
	Pesticides	0	109 058	109 058	109 058	109 058
	Licences and insurance	0	107 496	107 496	107 496	107 496
	Fuel & Lubricants	0	73 651	73 651	73 651	73 651
	Repairs machinery and equipment	0	176 935	176 935	176 935	176 935
	Labour (temp)	0	51 194	51 194	51 194	51 194
	Water?	0	52 549	52 549	52 549	52 549
	Electricity	0	101 670	101 670	101 670	101 670
	Packaging, storage & Harv	0	418 094	421 056	418 094	421 056
	Stock feed	8 500	0	0	8 500	8 500
	Supplies	0	0	0	0	0
	Other	0	0	0	0	0
Labour costs (permanent)	Wages	0	160 000	160 000	160 000	160 000
	Wages owing	0	0	0	0	0
	Farm products consumed	5 723	0	0	5 723	5 723
	Other	0	0	0	0	0
Depreciation	Fixed improvements	0	0	0	0	0
	Machinery and equipment	0	0	0	0	0
Repair and maintenance	Fixed improvements	0	0	0	0	0
	Machinery & equipment	0	0	0	0	0
Other expenses	Veterinary, medicine & AI	0	0	0	0	0
	Transport and contract work	0	0	0	0	0
	Marketing costs	0	0	0	0	0
	Packaging and storage	0	0	0	0	0
	Licenses and insurance	0	73 000	73 000	73 000	73 000
	Electricity	0	130 000	130 000	130 000	130 000
	Water	0	50 000	50 000	50 000	50 000
	Tel., post.+ stationery	0	15 200	15 200	15 200	15 200
	Fuel & Lubricants	0	94 349	94 349	94 349	94 349
	Other	0	21 000	21 000	21 000	21 000
Total Production, Marketing and admin costs		14 223	2 452 737	2 455 699	2 466 960	2 469 922
NET FARM INCOME	(NFI)	15 477	733 719	767 831	749 195	783 308
Less: Compulsory capital redemption						
	Interest (drainage Loan)	0	0	79 778	0	79 778
	Production loan / overdraft	0	162 781	169 163	162 781	169 163
	Rentals	0	0	0	0	0
	Share-cropping	0	0	0	0	0
Total Compulsory capital redemption		0	162 781	248 941	162 781	248 941
FARM PROFIT	(NFP)	15 477	570 938	518 891	586 415	534 367
Plus:	Non-farming income	0	0	0	0	0
	Capital appreciation	0	0	160 000	0	160 000
	Capital profits	0	0	0	0	0
	Own-capital inflow	0	0	0	0	0
Less:	Capital loss	0	0	0	0	0
	Own-capital outflow	0	0	0	0	0
	Dividends / profits	0	0	0	0	0
	Income tax provision	0	11 000	11 000	11 000	11 000
	Private & house expenses	0	242 500	242 500	242 500	242 500
	Farm products consumed	9 700	0	0	9 700	9 700
GROWTH IN NET WORTH	(GNW)	5 777	317 438	425 391	323 215	431 167
Reconciliation:						

Net worth - Previous balance sheet	0	170 465	170 465	170 465	170 465
Plus: Growth in net worth (drainage from status quo)	5 777	317 438	425 391	323 215	431 167
Net worth - Present balance sheet	5 777	487 903	595 855	493 680	601 632

Compiled by R.J. Armour, WRC Drainage Consultancy Project   Adapted from Finance & Farmers, Standard Bank (2005)

A one year cash flow analysis (Table 7.28) of the OV-WUA case study farm reveals that with an opening balance of R1 495 751 (sum of current liabilities) that there is a difference in the cash flow closing balance of just under R110 000 with drainage, ending with R681 654, compared to R572 463 without. The sum of the interest equals -R 169 163 (*-162 781*) and the largest negative monthly cash flow value is -R 1 881 053 (-R 1 880 551) for which overdraft facilities have to be arranged (value in brackets indicate same results without additional drainage).

Table 7.28. An annual cash flow statement (R/farm) for the for the OV-WUA case study farm

Cash Flow statement for the period:		May 2005-April 2006					**Without additional drainage**						
	TOTAL	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Operating income													
	3 223 530	0	0	805 883	0	0	805 883	0	0	805 883	0	0	805 883
	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0
Capital income	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Breeding stock	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Machinery and equipment	**0**	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-farm income	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Total income	**3 223 530**	**0**	**0**	**805 883**	**0**	**0**	**805 883**	**0**	**0**	**805 883**	**0**	**0**	**805 883**
Operating expenditure													
Directly allocatable inputs													
Seed	**241 453**	20 121	20 121	20 121	20 121	20 121	20 121	20 121	20 121	20 121	20 121	20 121	20 121
Fertiliser	**528 886**	44 074	44 074	44 074	44 074	44 074	44 074	44 074	44 074	44 074	44 074	44 074	44 074
Herbicides	**48 203**	4 017	4 017	4 017	4 017	4 017	4 017	4 017	4 017	4 017	4 017	4 017	4 017
Pesticides	**109 058**	9 088	9 088	9 088	9 088	9 088	9 088	9 088	9 088	9 088	9 088	9 088	9 088
Licences and insurance	**107 496**	8 958	8 958	8 958	8 958	8 958	8 958	8 958	8 958	8 958	8 958	8 958	8 958
Fuel & Lubricants	**73 651**	6 138	6 138	6 138	6 138	6 138	6 138	6 138	6 138	6 138	6 138	6 138	6 138
Repairs machinery and equipment	**176 935**	14 745	14 745	14 745	14 745	14 745	14 745	14 745	14 745	14 745	14 745	14 745	14 745
Labour	**51 194**	4 266	4 266	4 266	4 266	4 266	4 266	4 266	4 266	4 266	4 266	4 266	4 266
Water?	**52 549**	4 379	4 379	4 379	4 379	4 379	4 379	4 379	4 379	4 379	4 379	4 379	4 379
Electricity	**101 670**	8 472	8 472	8 472	8 472	8 472	8 472	8 472	8 472	8 472	8 472	8 472	8 472
Packaging and storage (& Harvesting)	**421 056**	35 088	35 088	35 088	35 088	35 088	35 088	35 088	35 088	35 088	35 088	35 088	35 088
Transport and contract work	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Marketing costs	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Purchased stock feed	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Veterinary, medicine & AI	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Unallocatable direct operating costs													
Repairs fto buildings and improvements	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Income tax	**11 000**	0	0	0	0	0	0	0	0	0	0	0	11 000
Telephone, postage and stationery	**15 200**	1 267	1 267	1 267	1 267	1 267	1 267	1 267	1 267	1 267	1 267	1 267	1 267
Rentals	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Salaries	**160 000**	12 500	12 500	12 500	12 500	12 500	12 500	12 500	22 500	12 500	12 500	12 500	12 500
Bank charges	**5 000**	417	417	417	417	417	417	417	417	417	417	417	417
Other	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Capital expenditure													
Livestock	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Machinery and equipment	**0**	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0
Debt Redemption													
Capital	**57 143**	0	0	14 286	0	0	14 286	0	0	14 286	0	0	14 286
Interest	**79 778**	0	0	19 944	0	0	19 944	0	0	19 944	0	0	19 944
Non-farm expenditure													
Total expenditure	2 240 271	173 529	173 529	207 759	173 529	173 529	207 759	173 529	183 529	207 759	173 529	173 529	218 759
Surplus / shortfall	**983 260**	-173 529	-173 529	598 123	-173 529	-173 529	598 123	-173 529	-183 529	598 123	-173 529	-173 529	587 123
Bank balance													
Opening balance	-1 495 751												
New balance		-1 669 280	-1 860 893	-1 282 929	-1 470 357	-1 659 815	-1 079 673	-1 264 899	-1 462 131	-879 847	-1 062 908	-1 247 952	-674 348
Positive Interest	**5.00%**	0	0	0	0	0	0	0	0	0	0	0	0
Negative interest	**13.00%**	-18 084	-20 160	-13 898	-15 929	-17 981	-11 696	-13 703	-15 840	-9 532	-11 515	-13 519	-7 306
Closing balance		-1 687 364	-1 881 053	-1 296 828	-1 486 286	-1 677 796	-1 091 369	-1 278 602	-1 477 971	-889 379	-1 074 423	-1 261 472	**-681 654**
												Without Drains	-572 463

Compiled by R.J. Armour, WRC Drainage Consultancy Project   Adapted from Finance & Farmers, Standard Bank (2005)

Financial ratios in Table 7.29 indicate the following:

- Solvency; a weakening net capital ratio going below the required benchmark, a worsening poor leverage ratio, an improved own capital ratio
- Liquidity; is only slightly reduced by the installation of drainage
- Profitability; is not really applicable as you cannot compare the status quo with additional drainage. Farm profitability with drainage is 5.34% and the profitability on own capital 67.50%.
- Efficiency; Capital turnover is unchanged, the cost ratio approaches 1 by only 0.01%, but the Debt servicing ration moves further away from 0 (from 0.051 to 0.119).

Table 7.29. The financial ratios for the OV-WUA case study farm

SOLVENCY	Status Quo	Additional drains	
Net Capital Ratio:	**2.15**	**1.62**	:1
Total assets	7 824 333	7 984 333	(>2)
Total Liabilities	3 635 751	4 917 457	
Leverage Ratio:	**10.66**	**10.95**	:1
Total Liabilities	3 635 751	4 917 457	(<1)
Own capital (Net worth)	340 929.76	448 882.22	
Own Capital Ratio:	**0.04**	**0.06**	:1
Own capital (Net worth)	340 929.76	448 882.22	(>0.5)
Total assets	7 824 333	7 984 333	
Buisness Growth:		**24.36**	%
NW with drains - NW without		107 952.46	(>inflation)
NW without		443 105.42	x 100/1

LIQUIDITY *(not really affected)*	Status Quo	Additional drains	
Current ratio:	**0.30**	**0.28**	:1
Current assest	452 333.33	452 333.33	(>2)
Current liabilities	1 495 750.71	1 634 600.15	
Acid test ratio:	**0.29**	**0.27**	:1
Current assets - stocks & supplies	433 533.33	433 533.33	(=1)
Current liabilities	1 495 750.71	1 634 600.15	
Intermediate ratio:	**0.85**	**0.78**	:1
Current + medium term assest	1 387 333.33	1 387 333.33	(>4)
Current + medium term liabilities	1 635 750.71	1 774 600.15	

PROFITABILITY *(not applicable)*	Status Quo	Additional drains	
Farm profitability (return on assets):		**5.34**	%
NFI		630 558	(R / R100)
Ave, total capital employed		11 816 500	x 100/1
Profitability on own capital:		**67.50**	%
Farm Profit		381 617	(>inflation)
Average own capital		565 371	x 100/1

EFFICIENCY	Status Quo	Additional drains	
Capital Trurnover ratio:	**0.41**	**0.41**	:1
Gross production value	3 216 155	3 253 230	(>>1)
Average total capital employed	7 824 333	7 984 333	
Cost ratio:	**0.87**	**0.88**	:1
Total expenditure	2 782 491	2 871 613	(<1)
Gross value of production	3 216 155	3 253 230	
Debt servicing ratio:	**0.051**	**0.119**	:1
Debt redemption (installment + interest)	162 781	385 861	(0<<)
Gross value of production	3 216 155	3 253 230	

A.4.4 STOCHASTIC ANALYSIS (BIO-PHYSICAL RISK)

Figure 7.6 shows the large variation in TDSe (=Cue) that can occur in the OV-WUA. These are three of the 100 simulated TDSe 20 year sequences used for analysis of the OV-case study farmer.

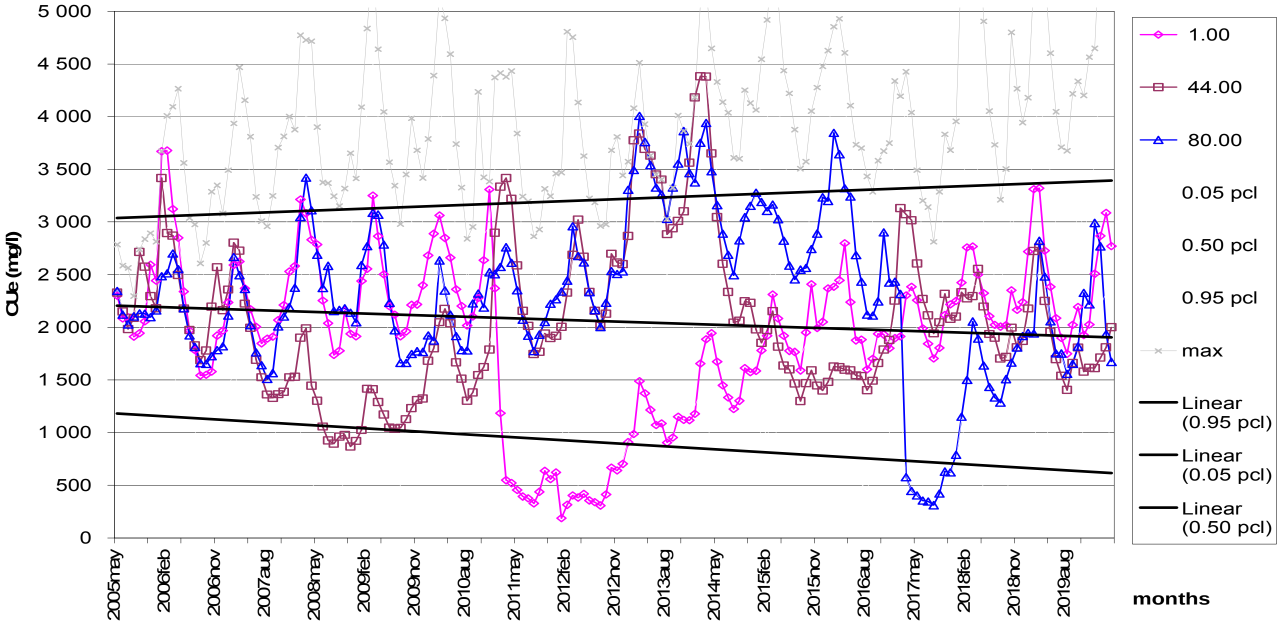

Figure 7.6. Stochastic spread of the saturated soil salinity - CUe (mg/l) – used for the status quo scenarios for the OV-WUA case study farmer

Taking the 0.50 percentiles of the stochastic sequence of the Status quo situation (SQ) as depicted in Figure 7.6, Figure 7.7 compares these to the 0.50 percentiles of the stochastic sequence of the Scenario 3 (i.e. additional drainage) situation (SQ). These are more realistic TDSe fluctuations than those shown in Figure 7.5 and are used in the stochastic analysis of the drainage feasibility model to highlight the extent of the bio-physical risk of possible salinisation fluctuations due to changes in the hydrology and rainfall (i.e. wet and dry cycles).

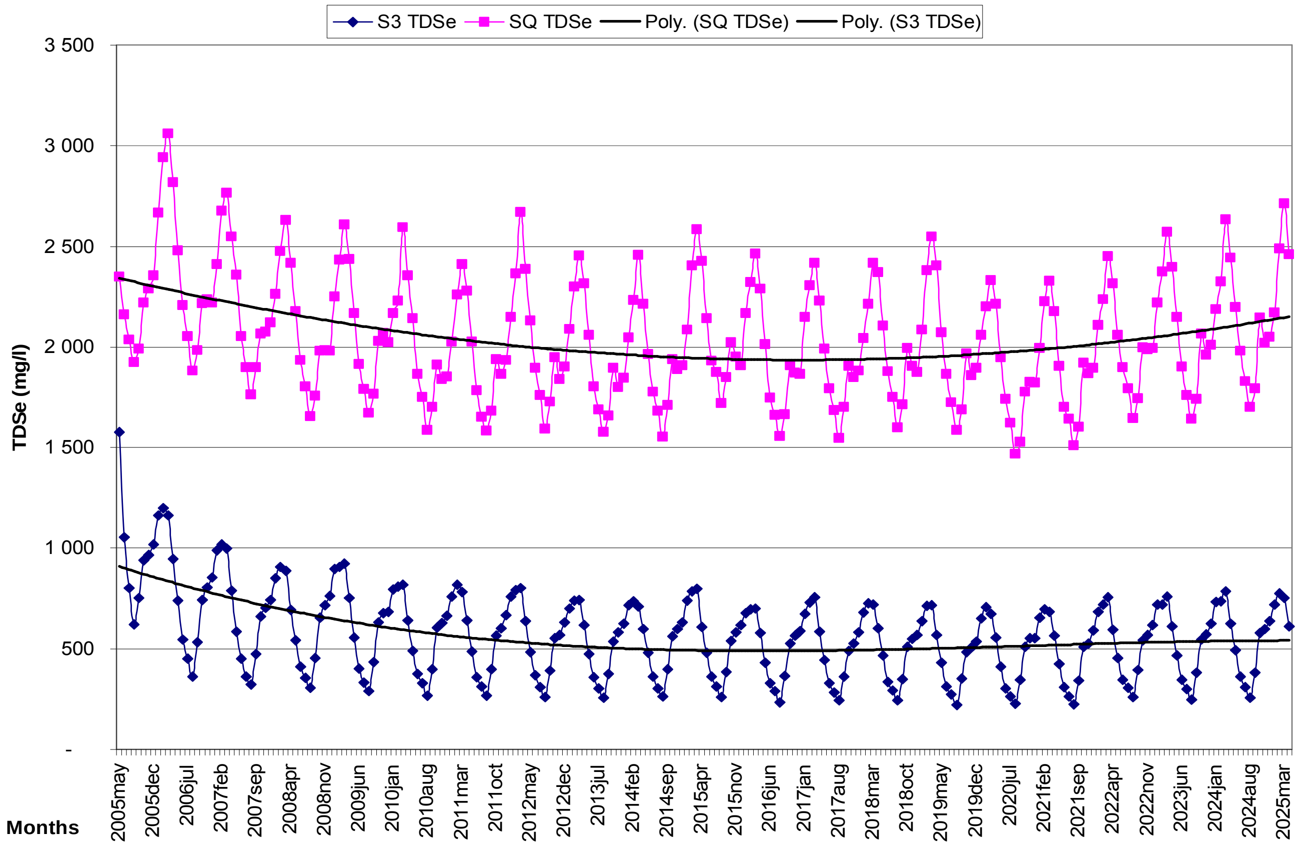

Figure 7.7 The TDSe 0.05 percentiles of the status quo (SQ) situation versus the additional drainage situation (S3) in the OV-WUA over 20 years

Using the soil water qualities above, the cropping combinations in Table 7.30 are run through the stochastic financial simulation model. SQ (Status Quo) is the cropping combination the OV-WUA case study farm currently plants, AD (Additional Drainage) is the same crop choice and hectarage but with the farmer selecting which crops he will plant on the additional newly drained soil, and AD+ (Additional Drainage + higher value crops) is the new (higher value) cropping composition the OV-WUA case study farm would like to plant once additional drainage is installed.

Table 7.30. Existing and proposed cropping data input for the OV-WUA case study farmer

Vall Farmer	Barley	Beets	Carrots	Cotton	Cucurbits	Dry_Beans	Fruit	Lucerne	Maize	Olives	Onions	Pastures	Peanuts	Pecan_nuts	Potatoes	Soybeans	Sunflower	Vegetables	Vineyards	Wheat	Total Area (ha)
Status Quo cropping composition																					
SQ BaseCase	-	10	-	-	-	-	-	40	-	-	-	-	-	-	-	-	-	-	-	-	50
SQ Scen3	-	-	-	-	-	5	-	-	90	-	5	-	-	-	-	-	-	-	-	110	120
Additional drainage-same crops					*40 ha additional*																
AD BaseCase	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
AD Scen3	-	-	-	-	-	5	-	40	90	-	5	-	-	-	-	-	-	-	-	110	160
Additional drainage-higher value crops					*40 ha additional*																
AD+ BaseCase	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
AD+ Scen3	-	-	-	-	-	10	-	30	90	-	10	-	-	-	-	-	-	-	-	110	160

The stochastically generated 100 GMs for each of the 20 years modelled for the OV-WUA case study framer appear in Figure 7.8. The top graph shows a wider spread of results as a result of not having drainage whereas the lower two graphs show a much smaller spread of GM outcomes, directly as a result of the installation of additional drainage.

The spread of annual GMs in the upper graph predominantly occurs between R1 200 000 and R1 300 000, in the middle graph (same crops but with 40ha lucerne now drained) the GMs predominantly occur just above R1 300 000, and in the bottom graph (more dry beans and onions on the drained soils and less lucerne) GMs predominantly occur just below R1 500 000.

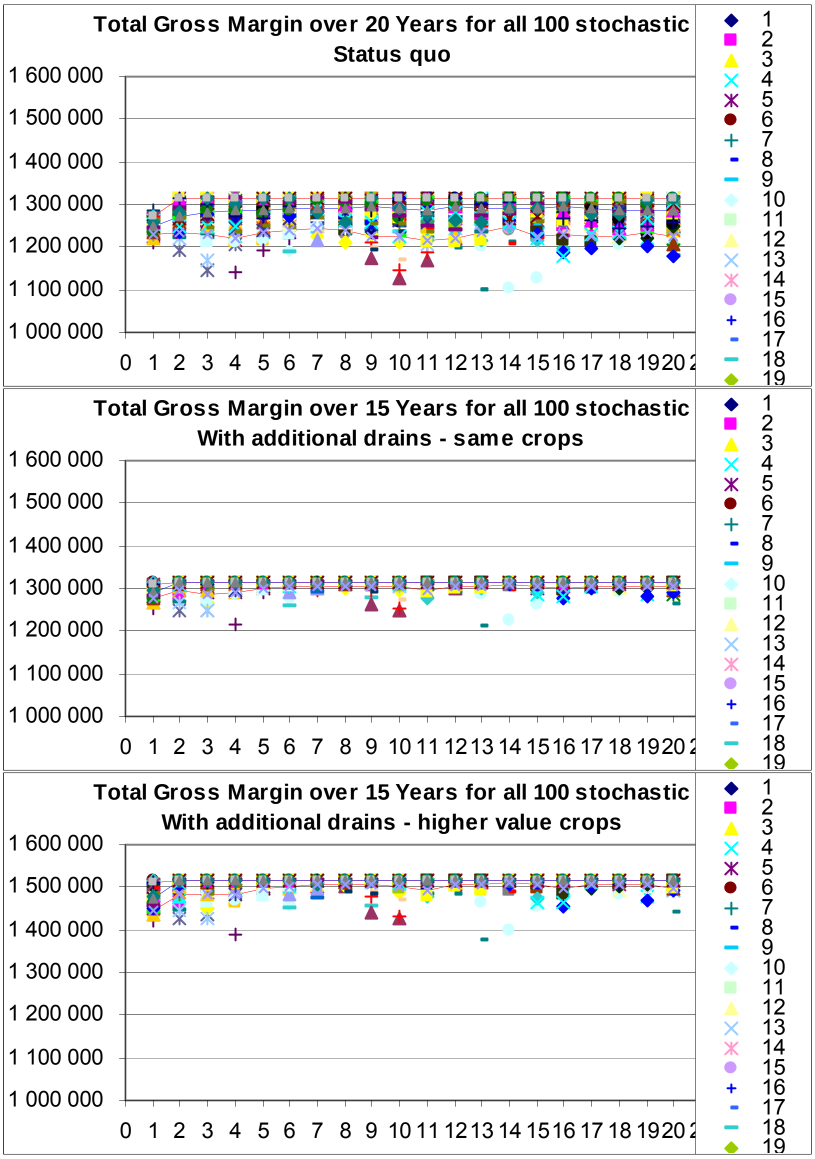

Figure 7.8. The stochastic GM (R/farm) results of the three scenarios for the OV-WUA case study farmer

The results in Figure 7.9 show the difference in the spread of results between the 3 scenarios. The figure on the left shows very steep curves for all three scenarios showing a small variation in GM results. Adding additional drainage to the status quo cropping choice show a small improvement from the status quo, but selecting higher value crops makes a large improvement in GM results. The small improvement with status quo crops with additional drainage is as a result of the OV-WUA case study farm planting lower value lucerne on the additionally drained land. Where he planted more onions and dry-bean on the newly drained soils the improvement in GM was significant.

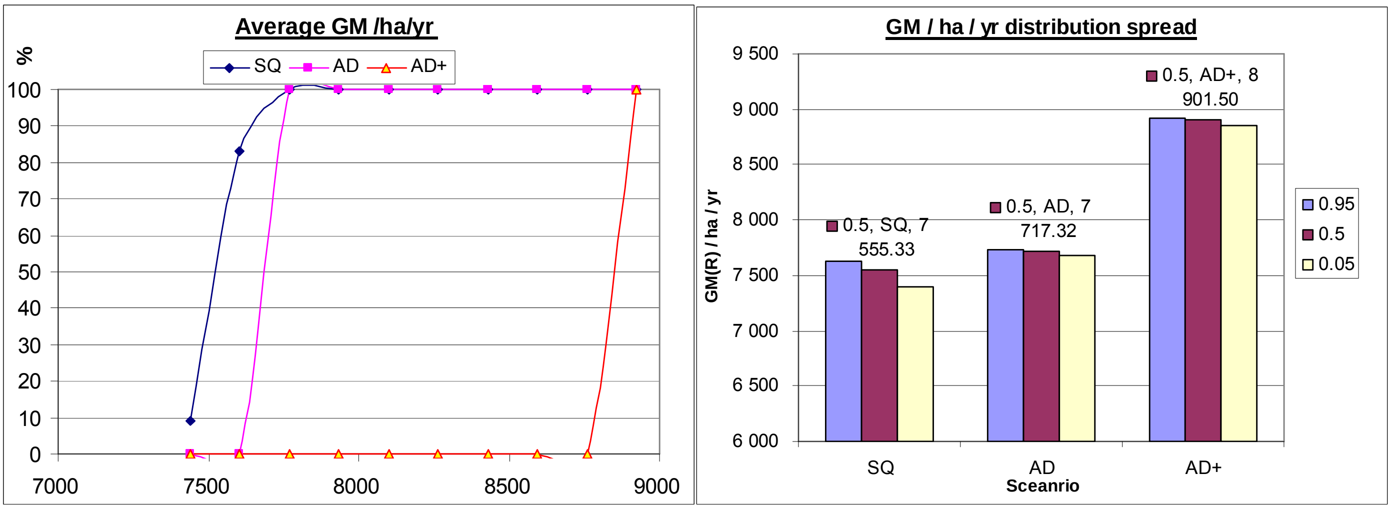

Figure 7.9. The spread of GM/ha/yr for the SQ, AD and AD+ situations modelled for 100 stochastic TDSe sequences

Table 7.31 analyse the long term cash flows of stochastic run number 80 (the sequence that most closely fits the 0.50 percentile of all GM sequences) using NPV, B:CR and IRR for various discount rates and comparing the two additional drainage scenarios with the status quo conditions..

Table 7.31. Partial analysis results of Status quo drainage (SQ) versus additional drainage with Status Quo crops (AD) and additional drainage with higher value crops (AD+) for the OV-WUA case study farmer

	AD minus SQ		AD+ minus SQ	
Discount rate	***NPV***	***B:C Ratio***	***NPV***	***B:C Ratio***
0.00%	-672 135	0.43	3 363 815	1.98
5.00%	-813 665	0.27	1 574 635	1.65
10.00%	-863 692	0.18	688 831	1.36
17.25%	-870 061	0.12	76 154	1.05
IRR	#NUM!	#NUM!	18.76%	1.00

Results in Table 7.31 show that without including higher value crops with drainage that even at a 0% discount rate the NPV with the additional drainage cannot exceed the NPV of the Status Quo. Costs exceed the benefits at all discout rates (B:CR <1) and an IRR cannot be calculated.

Planting higher value crops with the drainage, at a 0% discount rate the benefits used to calculate the net farm income (NFI) exceed the costs in a B:C ratio of 1.98 and a NPV of R3 363 815 is realised. At the bank discount rate of 17.25% the B:C ratio is reduced to 1.05 yielding NPV R76 154, with an NPV of R0 at a discount rate of 18.76%.

A.4.5 ECONOMIC IMPACTS

The direct/measurable socio-economic impacts of drainage on the OV-WUA case study farm are briefly discussed under the following headings:

Increased cost to society in drainage grant ***vs.*** savings to society
Job creation from drainage installation ***vs.*** jobs lost due to increased salinisation
Increased agricultural production for the area and resulting secondary effects benefits ***vs.*** rural economy lost due to increased salinisation.

At a grant of 50% of the full drainage costs of R28 571 per ha of draining 40 hectares on the OV-WUA case study farm, costs to society will be R572 857 once off.

Without the drainage in place, due to the close proximity of the land to be drained to the confluence of the Vaal and the Riet Rivers (see Figure 7.1) an entire crop can be lost in a 1 in 10 year flood. Lucerne establishment costs of nearly R4000/ha x 40 ha = R160 000 alone / 10 years = R16 000 per year.

The direct job creation in installing the drains will be 600 man days (6 people working for 5 months = 2.5 people employed for a year). The higher value crops planted with drainage (an additional 10ha of onions and dry beans) will necessitate the OV-WUA case study farm to spend R10 000 more per year on extra part time labour (= 1 extra person employed for a year). The value of direct additional employment is R40 000 in year 1 and R10 000 thereafter.

A nearly R7000 increase in taxable income (Table 7.22) is generated annually on the OV-WUA case study farm, at a 30% tax rate it is over R2000 additional tax income annually. The difference, i.e. R5 000 is additional money in circulation in the local economy. Additional expenses for inputs into the higher value crops will also result in greater economic activity in the region.

Besides these measurable socio-economic impacts there are also environmental impacts of drainage on the OV-WUA case study farm, namely:

Insurance of protection of soil resources and lowered water tables affecting neighbouring farmers
Increased saline agricultural return-flows
Change in water balance

The calculation of the full economic impact on society is out of the scope of this report, so the above is only aimed at highlighting some of the economic linkages of impacts from farm to regional level.

APPENDIX 5. ORANGE-RIET CASE STUDY FARM RESULTS

This section lists the farm level drainage feasibility analysis model results for the OR-WUA case study farm under the following main headings; Direct profitability -, Bank repayment Ability -, Financial analysis - and Stochastic analysis model results, ending off with and Economic interpretation of the results.

A.5.1 DIRECT PROFITABILITY MODEL RESULTS

Drainage costs are calculated in Table 7.32 for the O-R case study farm proposed additional drainage. The 15 hectares required to drain at a cost of R16 000 per ha will cost a total of R240 000 which the O-R case study farmer plans to pay off in cash. Only if he can achieve a 10% return on the capital (i.e. a 10% improvement to the *staus quo*) will he consider draining.

Table 7.32. Drainage costs for the OR-WUA case study farm

		the OR-WUA
Hectares to drain	ha	15
Average clay %	%	10%
Drainage Cost	/ha	**R 16 000**
Grant	%	0%
Value of grant	/ha	R 0
Total loan	/farm	**R 240 000**
Loan Term	years	20
Interest rate *(Subsidised)*	%	10.50%
Payments /year	terms	4
Repayments	/term	**R 7 207**
Hectares irrigable	ha	150
Percentage to drain	%	10%
Increase in value of land	/ha	R 4 000
Increase in value of land	/farm	**R 60 000**

Table 7.33 is the simple rate of return calculated for the main crops and cropping combinations planted on the O-R case study farm. The simple rate of return for additional yields from the combination of crops when including drainage is 1.70% amounting to increased returns of only R 272 per hectare. When however accounting for the costs of the drainage installation (i.e. R 1 879 / ha per year for 20 years) none of the crops individually besides maize and vineyards produce a positive direct profitability of increased earnings, indicating that although drainage increases the rate of return, the increased profits do not cover the costs of the drainage investment for barley, oats and lucerne for the OR-WUA CSF.

When looking at the direct profitability of GMASC after draining only oats' GMASC on its own doesn't cover the cost of the drainage as oats is a salt tolerant crop not befitted by drainage at the modelled level of ECe (mS/m).

The reason for calculating the ROR on increased earnings less drainage costs is to evaluate whether a farmer will at least be at the same level of immediate welfare with drainage to pay off versus carrying on without drainage. The results in Table 7.33 show that the increased GM returns from drainage are only sufficient to cover the costs of drainage for maize (at a price of R832/ton) and vineyards (at R725/ton).

At the bottom of the table are the breakeven loan repayments that the farmer can afford to maintain the same level of returns for each crop and cropping combination as without drainage. This is then re-calculated as the maximum loan amount that the farmer can afford for drainage per hectare. Subtracting this amount from the actual costs of drainage, leaves the amount of grant required for the farmer to breakeven. Results show that it is infeasible to drain oats and barley alone, necessitating a rotation with maize. The feasible crops to drain on a per hectare basis for the O-R case study farm are vineyards and maize. To breakeven with lucerne a minimal grant of R249 per ha is required, which might not justify the transactions costs of applying for the loan.

Table 7.33. The calculation of the simple rate of return (ROR) for the O-R case study farm

R =	Simple rate of return = (I - D) / O		1.70%			ECe (mS/m)	ECe (mS/m)	350
I =	Average Annual After tax earnings		R 272					
D =	Annual Average depreciation of the		R 0	*Last a lifetime if properly maintained*				
O =	Capital Outlay Required		R 16 000	*Subtract from taxable income*				
		Unit						
O =	Drainage costs	R/ha	R 16 000					
	Interest rate	*%/yr*	10.0%					
	Term	*Yr*	20					
	Capital repayment costs	R/ha/yr	R 1 879	5.0	18.7	7.0	16.5	
	Additional maintenance costs	R/ha	R 160	1%	of capital cost per year			
	Water & Electricity costs	R/mm/ha	0.68	0.82	**10%**	**Chose crop**	**Chose crop**	
	Crops to be planted on drained soils		**Maize**	**Oats**	**Lucerne**	**Barley**	**Vineyards**	
	Threshold	mS/m	170	600	200	800	150	
	Gradient	%/mS/m	0.12	0.071	0.073	0.071	0.096	
	Pre-drain Yield	ton/ha	**11.0**	**5.0**	**18.7**	**7.0**	**16.5**	
	After-drain Yield (Max yield)	ton/ha	14.0	5.0	21.0	7.0	20.4	
	Crop Water Use	mm/ha	749	601	1156	601	625	
	Leaching required to achieve max yield	%	**10%**	**5%**	**10%**	**5%**	**5%**	
	Crop Price (R/ton)	R/ton	832	1 650	950	1 700	725	
	Pre-drain Gross income	R/ha	9 134	8 250	17 765	11 900	11 941	
	After-drain Gross income	R/ha	11 651	8 250	19 950	11 900	14 778	
	Pre-drain Production costs - ex harvest	R/ha	6 161	5 563	4 124	4 099	8 934	
	Harvesting costs (R/ton)	R/ton	71	129	44	110	12	
	Pre-drain Production costs - inc. harvest	R/ha	6 942	6 208	4 949	4 872	9 128	
	After-drain Production costs (R/ha)	R/ha	7 317	6 388	5 288	5 052	9 355	**TOTAL**
	% area planted per year	%	**0%**	**70%**	**15%**	**5%**	**5%**	**95%**
	Gross Margin above specified costs pre drain	R/ha	2 192	2 042	12 817	7 028	2 813	**3 844**
	Gross Margin above specified costs after drain	R/ha	4 334	1 702	14 502	6 688	5 263	**3 964**
	Direct profitability of GMASC after drain		2 454	-177	12 622	4 809	3 383	**2 085**
	ROR on GMASC after drainage		15.34%	-1.11%	78.89%	30.05%	21.15%	**13.03%**
I =	Increased earnings (change in margin)		2 141	-180	1 845	-180	2 610	**272**
	ROR on increased earnings		13.38%	-1.13%	11.53%	-1.13%	16.31%	**1.70%**
	Direct profitability of increased earnings		**262**	**-2 060**	**-34**	**-2 060**	**731**	**-1 607**
	ROR on increased earnings less drainage costs		1.64%	-12.87%	-0.22%	-12.87%	4.57%	**-10.05%**
	Breakeven Repayments		R 2 141	R -180	R 1 845	R -180	R 2 610	**R 272**
	Max loan		R 18 231	R -1 535	R 15 706	R -1 535	R 22 222	**R 2 316**
	Grant per ha required		**R -2 231**	**R 17 535**	**R 294**	**R 17 535**	**R -6 222**	**R 13 684**

The SMCEB model calculates for each crop a gross margin (GM) per hectare and a 20 year cash flow with and without drainage. For a starting ECe value of 200 mS/m in the OR-WUA Table 7.34 list the crop level GM and ranks the crops in terms of direct profitability with and without drainage. Crops for which drainage will pay for itself (i.e. directly profitable) are all the crops that have a change greater than the drainage repayment costs (i.e. R1 879), namely Onions, Fruit, Carrots, Pecan nuts, Potatoes and Vineyards in order of profitability. For the drainage costs of the OV-WUA CSF vineyards were not included. It must however be noted that the additional costs of establishing the long term crops and changing irrigation systems would still have to be calculated.

Table 7.34. A crop level GM comparison for the OR-WUA CSF with ECe = 200

	GM with leaching	Rank	GM without leaching	Rank	Change	Rank
Barley	6 983	10	7 028	9	-45	14
Beets	6 805	11	6 834	11	-29	9
Carrots	10 684	8	6 919	10	3 765	3
Cotton	3 141	15	3 198	15	-56	18
Cucurbits	18 274	4	18 313	4	-38	11
Dry Beans	2 558	16	2 243	17	316	8
Fruit	37 477	2	33 705	2	3 772	2
Lucerne	14 813	5	14 900	5	-87	20
Maize	4 438	14	4 110	14	327	7
Olives	9 104	9	9 145	8	-41	12
Onions	50 793	1	42 406	1	8 388	1
Pastures	1 840	20	1 902	20	-62	19
Peanuts	2 041	18	2 085	18	-44	13
Pecan nuts	22 741	3	20 316	3	2 426	4
Potatoes	11 258	7	9 607	7	1 651	5
Soybeans	5 990	12	6 037	12	-47	17
Sunflower	2 269	17	2 299	16	-31	10
Vegetables	11 438	6	11 483	6	-45	16
Vineyards	5 557	13	4 906	13	651	6
Wheat / Oats	1 997	19	2 042	19	-45	14

Table 7.35 is a price:yield sensitivity and break-even (BE) analysis for the crops planted by the O-R case study farmer. How one interprets Table 7.35 for oats is as follows: The different possible oats prices are on the left, R600 to R2100, and possible yields in the row on the top, 4.0 to 7.0. The values within this matrix are the per hectare crop GMASC minus the per hectare annual repayment costs of drainage for the O-R case study farm. Negative values indicate price:yield combinations that are not directly profitable. The row at the bottom is the Break-Even analysis of GMASC with the drainage costs added (BE+D). For the O-R case study farm to break-even therefore with Oats at a 4 ton per ha yield a price of R2 136 is required. Alternatively, at a oats price of R1 500 per ton, the O-R case study farm needs to produce a yield of 4.35 t/ha without drainage and 5.86 t/ha to cover the installation costs of additional drainage.

Table 7.35. The price:yield sensitivity and Break-Even (BE) analysis for the crops planted by the O-R case study farm

Oats	GMASC-Drainage					
R *ton*	*4.0*	*5.0*	*6.0*	*7.0*	*BE*	*BE+D*
600	R -6 145	R -5 674	R -5 203	R -4 732	*12.67*	*17.05*
900	R -4 945	R -4 174	R -3 403	R -2 632	*7.74*	*10.41*
1200	R -3 745	R -2 674	R -1 603	R -532	*5.57*	*7.50*
1500	R -2 545	R -1 174	R 197	R 1 568	*4.35*	*5.86*
1800	R -1 345	R 326	R 1 997	R 3 668	*3.57*	*4.81*
2100	R -145	R 1 826	R 3 797	R 5 768	*3.03*	*4.07*
BE+D	*R 2 136*	*R 1 735*	*R 1 467*	*R 1 276*		

Lucerne	GMASC-Drainage					
R *ton*	*10.0*	*15.0*	*20.0*	*25.0*	*BE*	*BE+D*
600	R -1 465	R 1 314	R 4 094	R 6 873	*8.83*	*12.64*
675	R -715	R 2 439	R 5 594	R 8 748	*7.78*	*11.13*
750	R 35	R 3 564	R 7 094	R 10 623	*6.95*	*9.95*
825	R 785	R 4 689	R 8 594	R 12 498	*6.28*	*9.00*
900	R 1 535	R 5 814	R 10 094	R 14 373	*5.73*	*8.21*

975	R 2 285	R 6 939	R 11 594	R 16 248	*5.27*	*7.55*
BE+D	*R 747*	*R 512*	*R 395*	*R 325*		

Vineyards GMASC-Drainage

R ton	*10.0*	*15.0*	*20.0*	*25.0*	*BE*	*BE+D*
700	R -4 536	R -1 095	R 2 347	R 5 788	*13.60*	*16.59*
800	R -3 536	R 405	R 4 347	R 8 288	*11.87*	*14.49*
900	R -2 536	R 1 905	R 6 347	R 10 788	*10.53*	*12.85*
1000	R -1 536	R 3 405	R 8 347	R 13 288	*9.47*	*11.55*
1100	R -536	R 4 905	R 10 347	R 15 788	*8.60*	*10.49*
1200	R 464	R 6 405	R 12 347	R 18 288	*7.88*	*9.61*
BE+D	*R 1 154*	*R 773*	*R 583*	*R 468*		

Barley GMASC-Drainage

R ton	*5.5*	*6.0*	*6.5*	*7.0*	*BE*	*BE+D*
1100	R -1 123	R -628	R -133	R 362	*4.55*	*6.63*
1300	R -23	R 572	R 1 167	R 1 762	*3.79*	*5.52*
1500	R 1 077	R 1 772	R 2 467	R 3 162	*3.24*	*4.72*
1700	R 2 177	R 2 972	R 3 767	R 4 562	*2.83*	*4.13*
1900	R 3 277	R 4 172	R 5 067	R 5 962	*2.52*	*3.67*
2100	R 4 377	R 5 372	R 6 367	R 7 362	*2.26*	*3.30*
BE+D	*R 1 304*	*R 1 205*	*R 1 120*	*R 1 048*		

* BE is the breakeven yield of the Status Quo at different crop prices

** BE+D is the breakeven crop price at different yields or the breakeven yield at different prices of the additional (+D) drainage scenario.

A.5.2 BANK REPAYMENT ABILITY MODEL RESULTS

The bank repayment ability model, BankMod, as set up for the O-R case study farm produced the results shown in Table 7.36.

Table 7.36. The Bank repayment ability cash flow model analysis results for the O-R case study farm of the Status Quo (SQ) situation versus the Additional drainage (+D) scenario

	Status Quo (SQ)	Additional drainage (+D)		SQ	+D
MIN Cash Flow	***-324 208***	***-613 542***	***Net Present Value (NPV)***	***2 025 479***	***2 300 755***
MAX Cash Flow	***10 200 549***	***10 735 888***	***Internal Rate of Return (IRR)***	***8.88%***	***8.09%***

Interest rates		Annual capital cost replacement	R 2 449 000	
+ve	1%		R 230 000	
-ve	15%		Annual discount rate	10%
			Monthly discount rate	0.83%

	YEAR 1	YEAR 1	YEAR 1	STARTING	YEAR 1	10%			
	Income Streams	***Less: Direct Costs***	***Less: Overheads / Indirect Costs***	***Cash Flow***	***Bank Interest***	***Less: depreciation on loose assets***	***Value of movable assets***	***= Surplus before tax***	***NPV***
SQ	*2 210 100*	*-1 046 945*	*-480 000*	*0*	*-10 054*	*0*	*2 198 502*	*279 428*	*2 025 479*
+D	***2 042 500***	***-808 891***	***-510 949***	***-240 000***	***-41 269***		***2 198 502***	***318 217***	***2 300 755***

The Net Present Value (NPV) of the surpluses over 20 years equals the amount of Capital Debt that the farmer can repay, thus the farmers Repayment Ability. The Repayment Ability for the O-R case study farm is therefore R2 300 755 with drainage installed, which is higher than his NPV without drainage at R2 025 479. This is the maximum amount of debt that the bank will allow O-R case study farm. As he plans to finance the drainage with his own funds, this model is only run to see if he realizes as 10% return on his capital invested in the drainage. At the status quo, the O-R case study farm achieves an 8.88% internal rate of return, while with drainage installed he will only achieve an IRR of 8.09%. With drainage, the O-R case study farm's maximum negative cash flow value is R613 542, so he will therefore have to make provision for an additional cash injection of ±R290 000 (difference between status quo and additional drainage minimum cash flow situations) at the appropriate time to plan his cash flow accordingly. Although O-R case study farmer's NPV improves with drainage by more than the cost of the drainage, his IRR decreases and he is not able to generate the required return on his investment. At the end of 20 years the O-R case study farm could have R 535 000 more in the bank (Max Cash Flow +D) than carrying on *status quo*.

A drainage grant breakeven analysis is not necessary as the OR-Case study farm achieves a better NPV with drainage than without. Therefore just for the sake of salinity management it is not financially viable to drain in on the OR-Case study farm, but if water-logging is present then it would be feasible.

A.5.3 FINANCIAL ANALYSIS RESULTS

In this section, the results for the OR-Case study farm of the two versions of the financial analysis model are discussed;

- the CEB based model, SMCEBs, in which self simulated soil salinisation values / sequences / trends are inputted, reports results as NPV, IRR and B:C ratios for different levels of farm financial analysis (GM, NFP and FP levels), and
- the financial analysis model, FinAnalysis, reports balance sheet, income statement and cash-flow results for the O-R case study farm.

A.5.3.1 SMCEBs model results for the O-R CSF (case study farm)

The reason for including the SMCEBs model is to have a financial analysis model for which you can simulate your own progression of ECe over 20 years. Figure 7.13 is a theoretical simulation of ECe if the OR-CSF doesn't drain (the NO drainage line where ECe progressively gets worse), versus the theoretical improvement with drainage (the WITH drainage line where ECe improves dramatically in the first few years as salts get leached out, and then flattens out to equilibrium conditions with the irrigation water salinity)

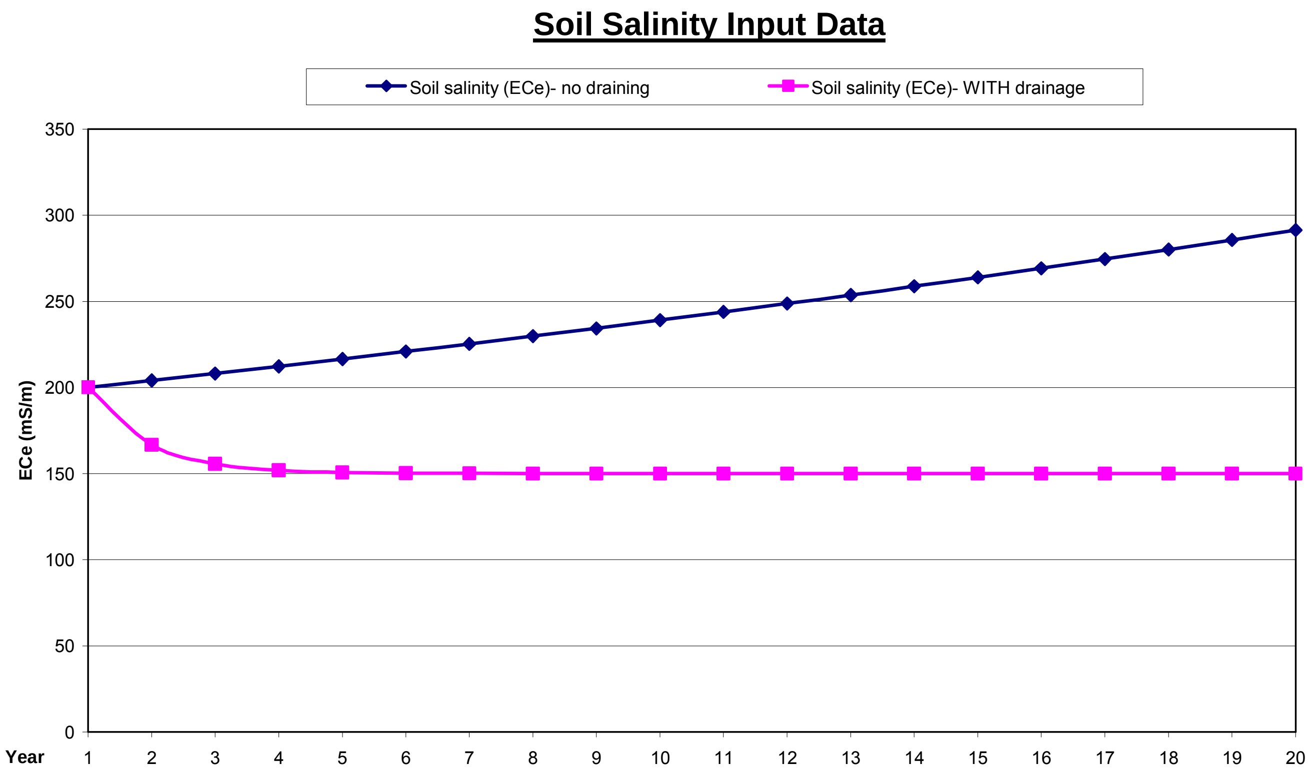

Figure 7.10. Simulated ECe data for 20 years for input into the SMCEBs model for the OR-WUA

The other reason for the SMCEBs model is to further the direct profitability models to whole farm level, as well as to expand the level of financial analysis from gross margin (GM) level to include fixed costs and calculate the net farm income (NFI) and also to bring in capital costs to calculate the Farm Profit (FP); and tax provision and household expenses to calculate Net worth (NW) as appear in Table 7.37.The difference in GM and NFI between drained and undrained is -R129 010 and for the farm profit and net worth –R153 010.

Table 7.37. The SMCEBs cash flow model results (R/ farm) for the OR-Case study farm

Total Income	no drains				2 437 173
	with drains				2 316 423
Total Var Costs	no drains				984 882
	with drains				993 142
Gross Margin	no drains	GM			1 452 291
	with drains	GM+			1 323 281
				Difference	*-129 010*
		15	ha's drained		
Fixed Costs	no drains	*cost/ha*	*Return*	*Payment R/yr*	480 000
	with drains	16 000	10.00%	R -28 190	480 000
Net Farm Income	no drains	NFI			972 291
	with drains	NFI+		*240 000*	843 281
				Difference	*-129 010*
Capital redemption					
Remuneration to hired management			35 000	x 12	420 000
Rentals					0
Interest on Capital	no drains				0
	with drains				24 000
Farm Profit	no drains	FP			552 291
	with drains	FP+			399 281
				Difference	*-153 010*
+Non farm income			0		0.00

- Capital loss			0		0.00
- Income tax provision			30%		162 547
- Private & household expenses			12 000	x 12	144 000
Net Worth	no drains	NW			245 744
	with drains	NW+			92 734
				Difference	*-153 010*

Figure 7.11 shows the decline in gross margin (GM) and GM+ with additional drainage over 20 years together with the difference between drainage GM (GM+) and no drainage GM. With drainage the O-R case study farm receives nearly R120 000 less in GM in the beginning than without drainage. Towards the end the addition of drainage does improve the difference by just over R20 000, cumulatively amounting to a loss of – R 2 136 646.

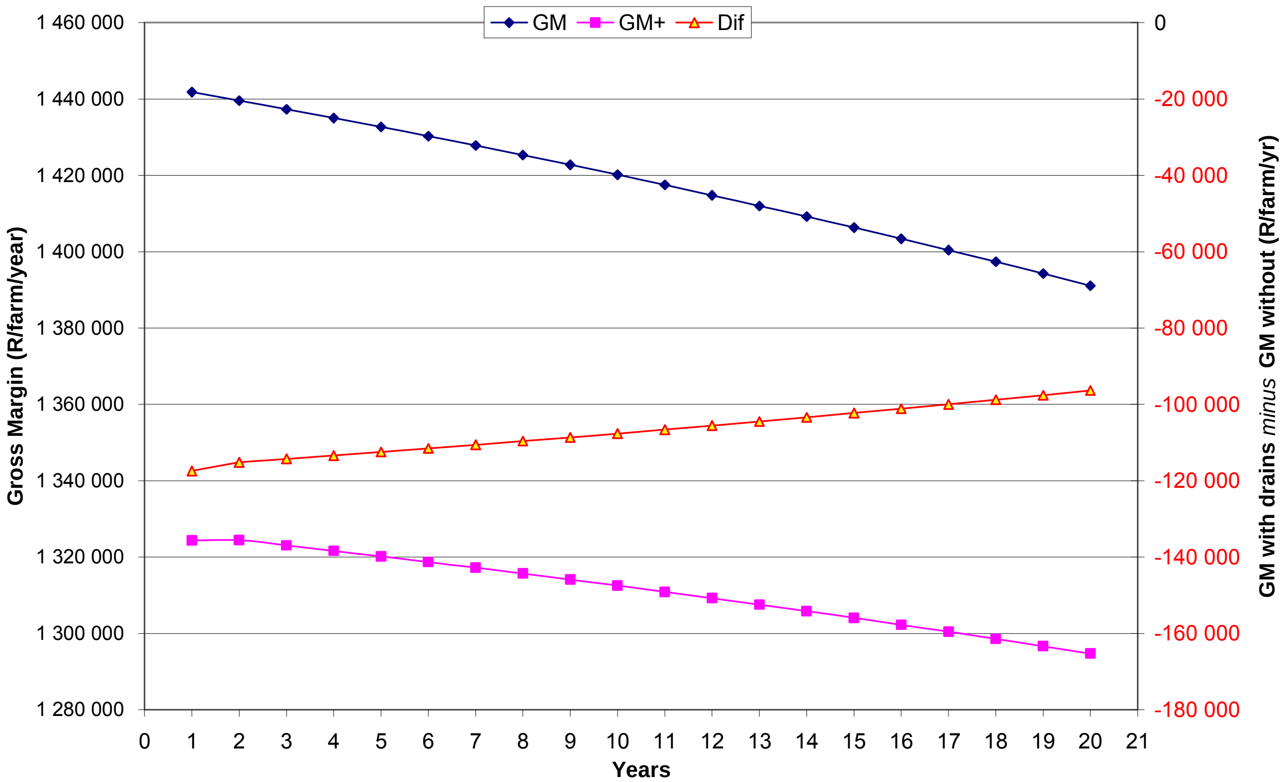

Figure 7.11. The Gross Margin cash flow of drainage versus no drainage for the O-R case study farm

The analysis of the results of Table 7.37 in Table 7.38 take the financial analysis further, from NFI level to Farm Profit (FP) level where the interest component of additional drainage is also subtracted.

Table 7.38 The SMCEBs cash flow model analysis results (R/farm) for the O-R case study farm

			NPV	B:C ratio (:1)	*IRR*
GM Cash Flow	no drains	**GM**			*n/a*
	with drains	**GM+**			*n/a*
	Difference	***GM+ - GM***			
no drains	**GM**	**0%**	28 359	2.44	
		10%	12 138	2.45	***End value***
		17%	8 046 460	2.45	**28 359 032**
with drains	**GM+**	0%	26 222	2.32	**26 222 386**
		10%	11 202	2.33	***-2 136 646***
		17%	7 418 599	2.33	
			NPV	**B:C ratio (:1)**	***IRR***

					NPV	B:C ratio (:1)	IRR
NFI Cash Flow	no drains	**NFI**					*n/a*
	with drains	**NFI+**					*n/a*
	Difference						
no drains	**NFI**		0%	18 759	1.64		
			10%	8 052 396	1.65		***End value***
			17%	5 345 131	1.65		**18 759 032**
with drains	**NFI+**		0%	16 382	1.56		**16 382 386**
			10%	6 897 981	1.57		***-2 376 646***
			17%	4 512 143	1.57		

				NPV	**B:C ratio (:1)**	***IRR***
FP Cash Flow	no drains	**FP**				*n/a*
	with drains	**FP+**				*n/a*
	Difference					
no drains	**FP**	0%	10 359	1.64		
		10%	4 476 699	1.65		***End value***
		17%	2 981 469	1.65		**10 359 032**
with drains	**FP+**	0%	7 502 386	1.20		**7 502 386**
		10%	3 117 959	1.20		***-2 856 646***
		17%	2 013 414	1.21		

A.5.3.2 Financial analysis model results

With the financial analysis data collected for the O-R case study farm, the income statement, balance sheet and cash flows are compiled. Based on drainage requirements and costs, the loan repayment schedule divided into the interest and capital components, is given for the O-R case study farm additional 15ha at total cost of R240 000 in Table 7.39. The additional annual returns to achieve a 10% return on investment for the own capital the O-R case study farm wants to invest in the drainage is R 28 190 of which the average capital repayment (principal) is R12 000 per year and the average interest repayment (cost of capital) is R15 793 per year. These average values are used in the balance sheet and income statements while the actual repayment schedule is used in the long term cash flow statements.

Table 7.39. The loan repayment sequence (R) for the O-R case study farm, divided into capital and interest components

Total Loan	**R 240 000**			Hectares to drain (ha)	15
Deposit	**-**	**GRANT / Farmers contribution**		Average clay (%)	10%
Principal	**240 000**	**/ year**	**/ month**	Drainage Cost (R/ha)	R 16000
Interest	**10.00%**	0.83%	2.50%	Value of grant (R/ha)	0
Years	**20**	240	80		
Payments/yr	1	12	4		
Payment	**28 190**	**2 316**	**6 966**		

Mnth Totals	***Still owe***	***Interest***	***Capital***	***Total cost***	***Compounded monthly (12 payments per year)***		
		1 595 556	***1 142 857***	***2 738 413***	***Year***	***Interest***	***Capital***
1	240 000	2 000	316		1	23 821	3 971
2	239 684	1 997	319		2	23 405	4 387
3	239 365	1 995	321		3	22 946	4 847
4	239 044	1 992	324		4	22 438	5 354
5	238 720	1 989	327		5	21 878	5 915
6	238 393	1 987	329		6	21 258	6 534
7	238 064	1 984	332		7	20 574	7 218
8	237 732	1 981	335		8	19 818	7 974
9	237 397	1 978	338		9	18 983	8 809
10	237 059	1 975	341		10	18 061	9 732
11	236 718	1 973	343		11	17 042	10 751

12	236 375	1 970	346	12	15 916	11 876
13	236 029	1 967	349	13	14 673	13 120
14	235 679	1 964	352	14	13 299	14 494
15	235 327	1 961	355	15	11 781	16 012
16	234 972	1 958	358	16	10 104	17 688
17	234 614	1 955	361	17	8 252	19 540
18	234 254	1 952	364	18	6 206	21 586
…	…	…	…	19	3 946	23 847
238	6 834	57	2 259	20	1 449	26 344
239	4 575	38	2 278	TOTAL	**315 852**	**240 000**
240	2 297	19	2 297	AVERAGE	**15 793**	**12 000**

The balance sheet for the OR-WUA CSF in Table 7.40 comparing the farm business with and without drainage is only slightly changed by the addition of the drainage loan to the long term liabilities with a subsequent increase in the current liabilities loan repayments. On the assets side the value of fixed improvements are not increased by the full cost of the drainage, but only by a mere R4 000/ha. Growth in net worth is a loss of R 279 390 with drains.

Table 7.40. Balance sheet (R/farm) for the OR case study farm

Balance sheet for	the O-R case study farm				28-Feb-07
LIABILITIES	*Without*	*With Drainage*	**ASSETS**	*Without*	*With Drainage*
Current Liabilities			**Current assets**		
Banks	0	0	Cash on hand / in bank	500 000	260 000
Cooperatives	0	0	Debtors	0	0
Creditors	0	0	Prepaid expenses	0	0
Income tax	0	0	Life insurance	0	0
Bills payable	0	0	Negotiable securities	0	0
Current portion of long tern liabilities	0	0	Stock:	0	0
Term loans	17 477	17 477	*Crops and crop products*	0	0
Instalment sale payment	0	0	*Fruit products*	0	0
Lease instalments	0	0	*Production inputs*	0	0
Bond repayments	0	0	*Marketable livestock*	0	0
Long-term loans	0	0	Other	0	0
Other loans	108 319	108 319	Short-term investment	0	0
Other	0	0	*Rotating fund*	0	0
	0	0	*Co-op Shares*	0	0
Total current liabilities	**125 796**	**125 796**	**Total current assets**	**500 000**	**260 000**
Medium-term liabilities			**Medium-term assets**		
Term loans	60 000	60 000	Breeding stock		
Instalment sale credit	0	0	Vehicles, mach. & equipment	2 449 000	2 449 000
Leases			Other: Office furniture		
Other	0	0	Other		
Total medium-term liabilities	**60 000**	**60 000**	**Total medium-term assets**	**2 449 000**	**2 449 000**
Long term liabilities			**Fixed assets**		
Bonds	0	0	Fixed improvements	1 970 000	1 970 000
Long-term loans	700 000	700 000	Land	8 581 000	8 581 000
Other	0	0	Other	0	0
Drainage loan	0	0	Increase in drained land value	0	60 000
	0	0		0	0
Total long-term liabilities	**700 000**	**700 000**	**Total Fixed assets**	**10 551 000**	**10 611 000**
Total Liabilities	885 796	885 796			
Net worth (from income statement)	593 368	313 979			
Total Liabilities + Net Worth	**1 479 165**	**1 199 775**	**Total Assets**	**13 500 000**	**13 320 000**
			Value of hired land	0	0
Growth in net worth with drains		**-279 390**	**Total capital employed**	**13 500 000**	**13 320 000**
Compiled by R.J. Armour, WRC Drainage Consultancy Project			Adapted from Finance & Farmers, Standard Bank (2005)		

Looking at the income statement in Table 7.41, total sales (and also GPV) is actually reduced by R120 750 by installing drainage. Total production costs decrease by R3 888 due to a bad selection of alternative crop, relating to a decrease in Net Farm Income (NFI) of R116 862. Adding the interest costs/earnings (R17 472 is lost) to NFI the gap between the *status quo* (SQ) and AD (additional drainage) is increased to a change in Net Farm Profit (NFP) of just over R134 335. The capital appreciation of the value of the farm brought about by the drainage minus the reduction in own capital used to install the drainage, results in the widening of the gap between SQ and AD so that with additional drainage the farm Growth Net Worth (NW) is a loss R314 335.

Table 7.41. Income statement (R/farm) for the OR-WUA case study farm

Income statement for the period		May 2005- April 2006				
Description		Livestock	Crops		TOTAL	
		Constant	*Without Drainage*	*With Drainage*	***Without Drainage***	***With Drainage***
Sales	Cash	0	2 437 173	2 316 423	**2 437 173**	**2 316 423**
	Credit	0	0	0	**0**	**0**
	Account	0	0	0	**0**	**0**
	Transport and contract work	0	0	0	**0**	**0**
	Other	0	0	0	**0**	**0**
TOTAL Sales		0	2 437 173	2 316 423	**2 437 173**	**2 316 423**
Consumption	Household	0	0	0	**0**	**0**
	Labour	0	0	0	**0**	**0**
	Internal	0	0	0	**0**	**0**
TOTAL consumption		0	0	0	**0**	**0**
Stock adjustment						
	Closing stock	0	0	0	**0**	**0**
Less:	Opening stock	0	0	0	**0**	**0**
Less:	Purchases	0	0	0	**0**	**0**
TOTAL stock adjustment		0	0	0	**0**	**0**
TOTAL GROSS PRODUCTION VALUE	**(GPV)**	**0**	**2 437 173**	**2 316 423**	**2 437 173**	**2 316 423**
Less: Production, marketing and administration costs						
Production inputs	Seed	0	118 917	120 858	**118 917**	**120 858**
	Fertiliser	0	257 111	257 264	**257 111**	**257 264**
	Herbicides	0	51 850	50 641	**51 850**	**50 641**
	Pesticides	0	28 203	30 371	**28 203**	**30 371**
	Licences and insurance	0	43 619	48 735	**43 619**	**48 735**
	Fuel & Lubricants	0	56 929	53 051	**56 929**	**53 051**
	Repairs machinery and equipment	0	144 087	135 140	**144 087**	**135 140**
	Labour (temp)	0	21 508	21 508	**21 508**	**21 508**
	Water?	0	32 855	33 898	**32 855**	**33 898**
	Electricity	0	63 567	65 584	**63 567**	**65 584**
	Packaging, storage & Harv	0	127 711	125 420	**127 711**	**125 420**
	Stock feed	0	0	0	**0**	**0**
	Supplies	0	0	0	**0**	**0**
	Other	0	0	0	**0**	**0**
Labour costs (permanent)	Wages	0	0	0	**0**	**0**
	Wages owing	0	0	0	**0**	**0**
	Farm products consumed	0	0	0	**0**	**0**
	Other	0	0	0	**0**	**0**
Depreciation	Fixed improvements	0	0	0	**0**	**0**
	Machinery and equipment	0	0	0	**0**	**0**
Repair and maintenance	Fixed improvements	0	0	0	**0**	**0**
	Machinery & equipment	0	0	0	**0**	**0**
Other expenses	Veterinary, medicine & AI	0	0	0	**0**	**0**
	Transport and contract work	0	0	0	**0**	**0**

	Marketing costs	0	0	0	**0**	**0**
	Packaging and storage	0	0	0	**0**	**0**
	Licenses and insurance	0	0	0	**0**	**0**
	Electricity	0	0	0	**0**	**0**
	Water	0	0	0	**0**	**0**
	Tel., post.+ stationery	0	0	0	**0**	**0**
	Fuel & Lubricants	0	0	0	**0**	**0**
	Other	0	480 000	480 000	**480 000**	**480 000**
Total Production, Marketing and admin costs		14 223	0	1 426 358	1 422 471	**1 426 358**
NET FARM INCOME	**(NFI)**	0	1 010 815	893 952	**1 010 815**	**893 952**
Less: Compulsory capital redemption						
	Bank Interest (interest earned -ve sign)		-21 446	-3 974	**-21 446**	**-3 974**
	Production loan / overdraft		0	0	**0**	**0**
	Rentals		0	0	**0**	**0**
	Share-cropping		0	0	**0**	**0**
Total Compulsory capital redemption (earnings)			-21 446	-21 446	-3 974	**-21 446**
FARM PROFIT	**(NFP)**		**1 032 261**	**897 926**	**1 032 261**	**897 926**
Plus:	Non-farming income		24 000	24 000	**24 000**	**24 000**
	Capital appreciation		0	60 000	**0**	**60 000**
	Capital profits		0	0	**0**	**0**
	Own-capital inflow		0	0	**0**	**0**
Less:	Capital loss		0	0	**0**	**0**
	Own-capital outflow		0	240 000	**0**	**240 000**
	Dividends / profits		0	0	**0**	**0**
	Income tax provision		0	0	**0**	**0**
	Private & house expenses		420 000	420 000	**420 000**	**420 000**
	Farm products consumed		0	0	**0**	**0**
GROWTH IN NET WORTH	**(GNW)**		**636 261**	**321 926**	**636 261**	**321 926**
Reconciliation:						
Net worth - Previous balance sheet			636 261	636 261	**636 261**	**636 261**
Plus: Growth in net worth (drainage from status quo)			636 261	321 926	**636 261**	**321 926**
Net worth - Present balance sheet			1 272 522	958 187	**1 272 522**	**958 187**

Compiled by R.J. Armour, WRC Drainage Consultancy Project   Adapted from Finance & Farmers, Standard Bank (2005)

A one year cash flow analysis (Table 7.42) of the O-R case study farm reveals that with an opening balance of -R 125 798 (sum of current liabilities) that there is a reduction in the cash flow closing balance of just over R 600 000 with drainage, ending with R 808 130, compared to R 1 410 465 without. The sum of the interest earned equals R 3 974 (R 21 446) and the largest negative monthly cash flow value is -R 365 416 (-R 284 770) for which overdraft facilities have to be arranged (value in brackets indicate same results without additional drainage).

Table 7.42. An annual cash flow statement (R/farm) for the for the OR-WUA case study farm

Cash Flow statement for the period:			May 2005-April 2006				Without additional drainage						
	TOTAL	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Operating income	**2 316 423**	0	0	579 106	0	0	579 106	0	0	579 106	0	0	579 106
Capital income	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Breeding stock	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Machinery and equipment	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Sale of water rights	**24 000**	2 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000
Non-farm income	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Total income	**2 340 423**	**2 000**	**2 000**	**581 106**	**2 000**	**2 000**	**581 106**	**2 000**	**2 000**	**581 106**	**2 000**	**2 000**	**581 106**
Operating expenditure													
Directly allocatable inputs													
Seed	**120 858**	10 072	10 072	10 072	10 072	10 072	10 072	10 072	10 072	10 072	10 072	10 072	10 072
Fertiliser	**257 264**	21 439	21 439	21 439	21 439	21 439	21 439	21 439	21 439	21 439	21 439	21 439	21 439
Herbicides	**50 641**	4 220	4 220	4 220	4 220	4 220	4 220	4 220	4 220	4 220	4 220	4 220	4 220
Pesticides	**30 371**	2 531	2 531	2 531	2 531	2 531	2 531	2 531	2 531	2 531	2 531	2 531	2 531
Licences and insurance	**48 735**	4 061	4 061	4 061	4 061	4 061	4 061	4 061	4 061	4 061	4 061	4 061	4 061
Fuel & Lubricants	**53 051**	4 421	4 421	4 421	4 421	4 421	4 421	4 421	4 421	4 421	4 421	4 421	4 421
Repairs machinery and equipment	**135 140**	11 262	11 262	11 262	11 262	11 262	11 262	11 262	11 262	11 262	11 262	11 262	11 262
Labour	**21 508**	1 792	1 792	1 792	1 792	1 792	1 792	1 792	1 792	1 792	1 792	1 792	1 792
Water?	**33 898**	2 825	2 825	2 825	2 825	2 825	2 825	2 825	2 825	2 825	2 825	2 825	2 825
Electricity	**65 584**	5 465	5 465	5 465	5 465	5 465	5 465	5 465	5 465	5 465	5 465	5 465	5 465
Packaging and storage (& Harvesting)	**125 420**	10 452	10 452	10 452	10 452	10 452	10 452	10 452	10 452	10 452	10 452	10 452	10 452
Transport and contract work	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Marketing costs	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Purchased stock feed	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Veterinary, medicine & AI	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Unallocatable direct operating costs													
Repairs fto buildings and improvements	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Income tax	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Telephone, postage and stationery	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Rentals	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Salaries	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Bank charges	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Other	**480 000**	40 000	40 000	40 000	40 000	40 000	40 000	40 000	40 000	40 000	40 000	40 000	40 000
Capital expenditure													
Livestock	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Machinery and equipment	**0**	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0
Debt Redemption													
Capital	**-12 000**	0	0	-3 000	0	0	-3 000	0	0	-3 000	0	0	-3 000
Interest	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Non-farm expenditure													
Total expenditure		118 539	118 539	115 539	118 539	118 539	115 539	118 539	118 539	115 539	118 539	118 539	115 539
Surplus / shortfall		-116 539	-116 539	465 567	-116 539	-116 539	465 567	-116 539	-116 539	465 567	-116 539	-116 539	465 567
Bank balance													
Opening balance	**-125 796**												
New balance		-242 335	-361 500	100 150	-15 972	-132 684	331 445	216 287	100 649	566 635	452 457	337 803	804 777
Positive Interest	**5.00%**	0	0	417	0	0	1 381	901	419	2 361	1 885	1 408	3 353
Negative interest	**13.00%**	-2 625	-3 916	0	-173	-1 437	0	0	0	0	0	0	0
Closing balance		-244 961	-365 416	100 568	-16 145	-134 121	332 826	217 188	101 068	568 996	454 342	339 210	**808 130**
												Without Drains	*1 410 465*

Compiled by R.J. Armour, WRC Drainage Consultancy Project — Adapted from Finance & Farmers, Standard Bank (2005)

Financial ratios in Table 7.43 indicate the following with the installation of drainage:

- Solvency; very strong, but a weakening net capital ratio, a worsening leverage ratio exceeding the benchmark of 1, and a worsening own capital ratio
- Liquidity; is only slightly reduced by the installation of drainage
- Profitability; is not really applicable as you cannot compare the status quo with additional drainage, however the return on assets with drainage is low at 4.43% and the profitability on own capital is 54.25% which is well above inflation.
- Efficiency; Capital turnover decreases away from the benchmark of 1, the cost ratio approaches 1 by 0.03%, but the Debt servicing ration moves further away from 0 (from 0.009 to 0.014).

All in all the financial ratios indicate the O-R case study farm will be in a worse financial situation with draining showing a negative business growth of -30.79%

Table 7.43. The financial ratios for the OR-WUA case study farm

Financial analysis for:							28-Feb-07
SOLVENCY	*Status Quo*	*Additional drains*		**PROFITABILITY**	*Status Quo*	*Additional drains*	
Net Capital Ratio:	**15.24**	**11.83**	**:1**	**Farm profitability (return on assets):**		**4.43**	**%**
Total assets	13 500 000	13 320 000	(>2)	NFI		893 952	(R / R100)
Total Liabilities	885 796	1 125 796		Ave. total capital employed		20 160 000	x 100/1
Leverage Ratio:	**0.75**	**1.24**	**:1**	**Profitability on own capital:**		**54.25**	**%**
Total Liabilities	885 796	1 125 796	(<1)	Farm Profit		889 979	(>inflation)
Own capital (Net worth)	1 186 736.92	907 347.02		Average own capital		1 640 410	x 100/1
Own Capital Ratio:	**0.09**	**0.07**	**:1**				
Own capital (Net worth)	1 186 736.92	907 347.02	(>0.5)				
Total assets	13 500 000	13 320 000					
Buisness Growth:		**-30.79**	**%**				
NW with drains - NW without		-279 389.90	(>inflation)				
NW without		907 347.02	x 100/1				
LIQUIDITY				**EFFICIENCY**			
Current ratio:	**3.97**	**2.07**	**:1**	**Capital Trurnover ratio:**	**0.18**	**0.17**	**:1**
Current assest	500 000.00	260 000.00	(>2)	Gross production value	2 437 173	2 316 423	(>>1)
Current liabilities	125 796.26	125 796.26		Average total capital employed	13 500 000	13 320 000	
Acid test ratio:	**3.97**	**2.07**	**:1**	**Cost ratio:**	**0.59**	**0.62**	**:1**
Current assets - stocks & supplies	500 000.00	260 000.00	(=1)	Total expenditure	1 447 805	1 426 445	(<1)
Current liabilities	125 796.26	125 796.26		Gross value of production	2 437 173	2 316 423	
Intermediate ratio:	**15.87**	**14.58**	**:1**	**Debt servicing ratio:**	**0.009**	**0.014**	**:1**
Current + medium term assest	2 949 000.00	2 709 000.00	(>4)	Debt redemption (installment + interest)	21 446	31 766	(0<<)
Current + medium term liabilities	185 796.26	185 796.26		Gross value of production	2 437 173	2 316 423	

A.5.4 STOCHASTIC ANALYSIS

Interesting in the OR-WUA case study is that the farmer has more water rights than required and therefore rents out his excess water rights (Table 7.44). The additional land he has available without water rights he irrigates, pumping from groundwater. Water rights are worth R23 000-30 000 / ha and are rented out for R800 per ha per year. Samples taking in 2004 and analysed by the DoA at Glen showed this groundwater to have an EC of 183 mS/m. Assuming the soil being irrigated with this water is in equilibrium, the ECe of soil should be equal, adding a new dimension to the model, namely land irrigated with groundwater, for which provision has not been made. Internationally this is common practise and farmers practise blending to get a suitable water quality to irrigate crops with. Mr Mulke in the Lower Riet River pumps his drainage from inspection holes back into his balancing dam for reuse.

Table 7.44. Irrigation water rights and irrigable areas setup

Total irrigable land currently	224	**224**	Max irrigable
Water Rights	170	**84**	To leave fallow or withdraw from farming
Additional water rights purchased	-30	**140**	Total water rights available
Currently drained	27	**197**	remaining artificially un-drained
Un-drained with sufficient natural	70	**127**	remaining with insufficient drainage
Additional drainage required	15	**112**	still remaining with insufficient drainage
	Statu	**Addition**	***Farms using pumped bore hole water!***
To plant as BC with total available	**43**	**28**	*can't have -ve value*
To plant as S3 with total available	**97**	**112**	*(forces drainage < water rights)*
	140	***140***	*Must be equal*
	84		*ha's available for irrigating with groundwater*
Starting year for analysis	**1**		*e.g. 1 or 2005*
Stochastic Run	**80**		*select 1 to 100*

Figure 7.12 shows the large variation in TDSe (=Cue) that can occur in the OR-WUA. These are three of the 100 simulated TDSe 20 year sequences used for analysis of the OV-case study farmer.

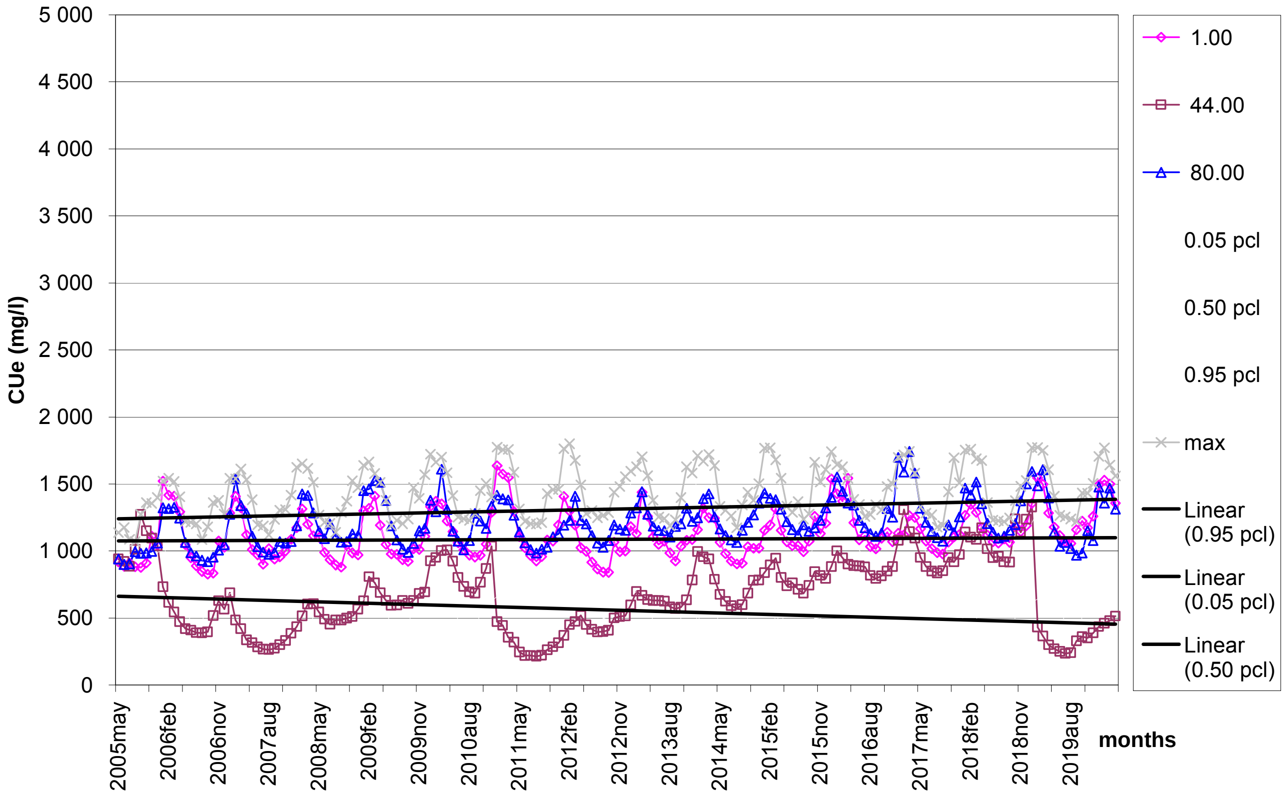

Figure 7.12. The stochastic spread of the saturated soil salinity - CUe (mg/l) – used for the OR-WUA case study farmer without drainage

Taking the 0.50 percentiles of the stochastic sequence of the status quo situation (SQ) as depicted in Figure 7.12, Figure 7.13 compares these to the 0.50 percentiles of the stochastic sequence of the Scenario 3 (i.e. additional drainage) situation (AD). These are the more realistic TDSe fluctuations than those shown in Figure 7.10 and are used in the stochastic analysis of the drainage feasibility model to highlight the extent of the bio-physical risk of possible salinisation fluctuations due to changes in the hydrology and rainfall (i.e. wet and dry cycles).

Figure 7.13 is the bio-physical drivers of the financial analysis, namely the TDSe of the Status Quo(SQ) and additional drainage(AD) scenarios compared in this analysis.

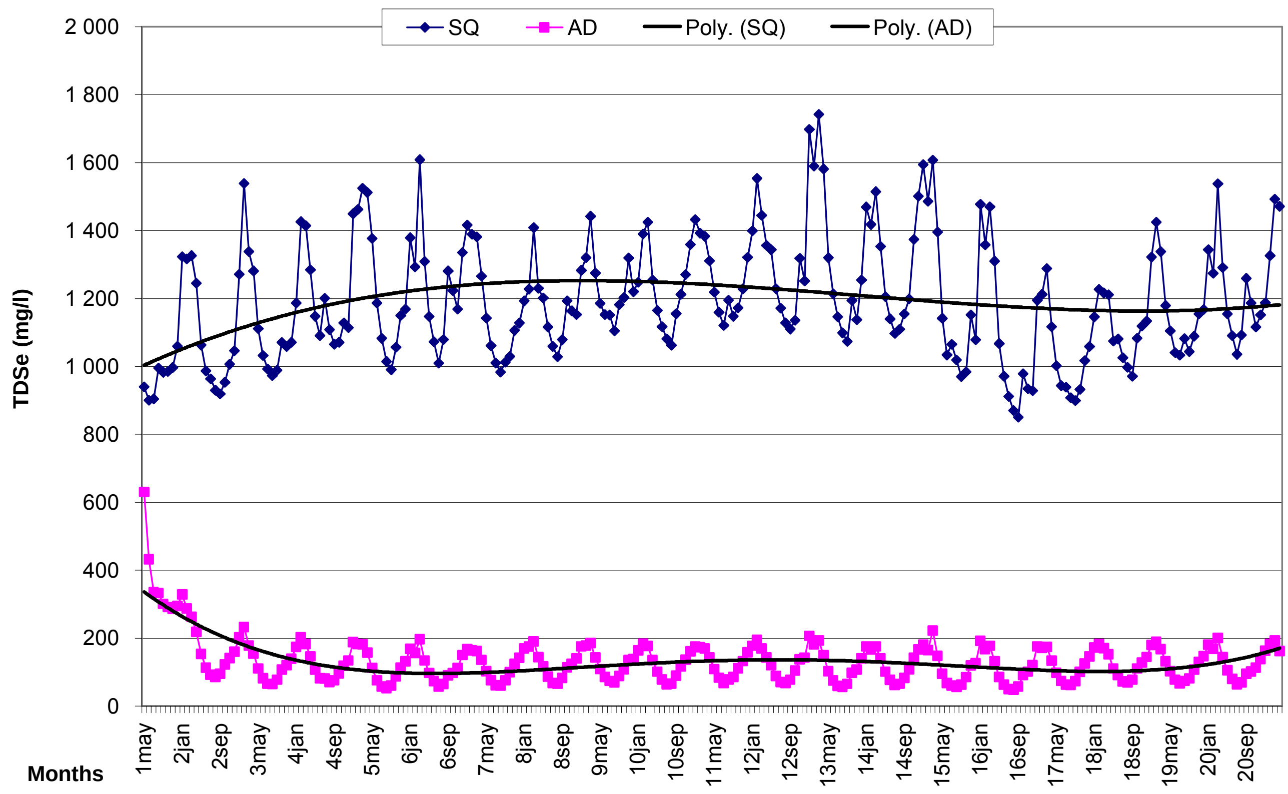

Figure 7.13. A 20-year simulation of the TDSe of the OR-WUA case study farm at status quo (SQ) levels and at additional drainage levels (AD)

Using the soil water qualities above, the cropping combinations in Table 7.45 are run through the stochastic financial simulation model. SQ (Status Quo) is the cropping combination the O-R case study farmer currently plants; AD (Additional Drainage) is the same crop choice and hectarage but with the farmer selecting which crops he will plant on the additional newly drained soil, and AD+ (Additional Drainage + higher value crops) is the new (higher value) cropping composition the O-R case study farm would like to plant once additional drainage is installed.

Table 7.45. Existing and proposed cropping data input for the OR-WUA case study farmer

	Vall Farmer	Barley	Beets	Carrots	Cotton	Cucurbits	Dry_Beans	Fruit	Lucerne	Maize	Olives	Onions	Pastures	Peanuts	Pecan_nuts	Potatoes	Soybeans	Sunflower	Vegetables	Vineyards	Wheat	*Total Area (ha)*
																		Status Quo cropping composition				
SQ	BaseCase								40													*40*
SQ	Scen3	30							30											15	56	*131*
	Additional drainage-same crops																			*15 ha additional*		
AD	BaseCase								25													*25*
AD	Scen3	45							30											15	56	*146*
Additional drainage-higher value crops																				*15 ha additional*		
AD+	BaseCase								15													*15*
AD+	Scen3	45							30											25	56	*156*

The results in Figure 7.14 show the difference in the in spread of results between the 3 scenarios. The figure on the left shows very flat curves for all three scenarios showing none to a very small variation in GM results. The worsening R/ha/yr results from status quo crops (SQ = ±R10 600) to additional drainage (AD = ±R9800) is due to the increased leaching costs with the drainage and when changing cropping combinations; the reduction is due to the O-R case study farmer wanting to plant lower value barley on the additionally drained land.

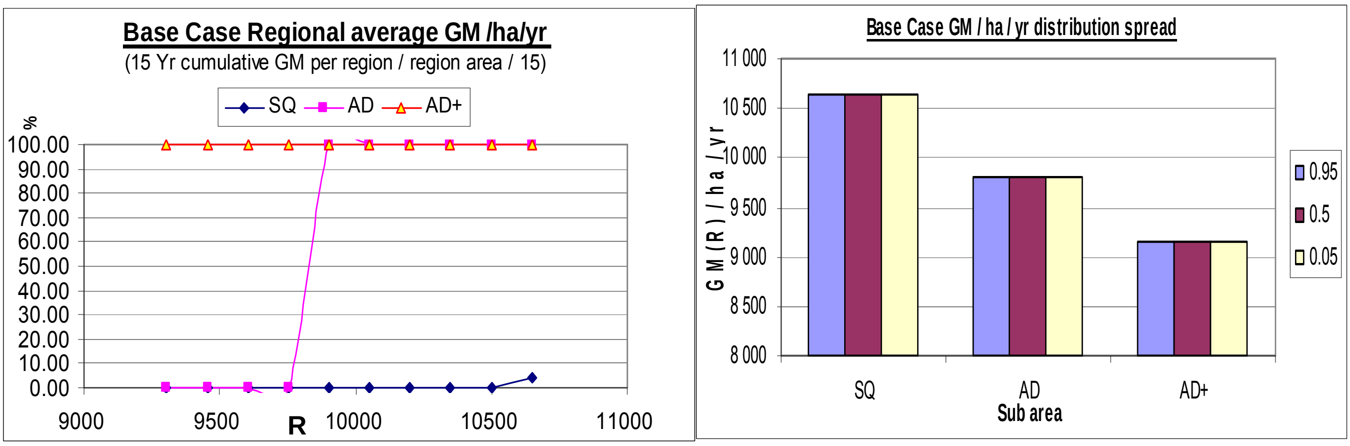

Figure 7.14. The stochastic GM (R/farm) results of the three scenarios for the OR-WUA case study farmer

The stochastically generated 100 GMs for each of the 20 years modelled for the OR-WUA case study farmer appear in Figure 7.15. None of the graphs show much spread of results due to good water quality not affecting the cropping combinations planted.

The annual GMs in the SQ graph occur just below R1 500 000, AD graph (same crops but with 15ha lucerne now drained) the GMs occur just below R1 400 000, and in the AD+ graph (more barley planted on the drained soils and less lucerne) GMs predominantly occur just below R1 300 000.

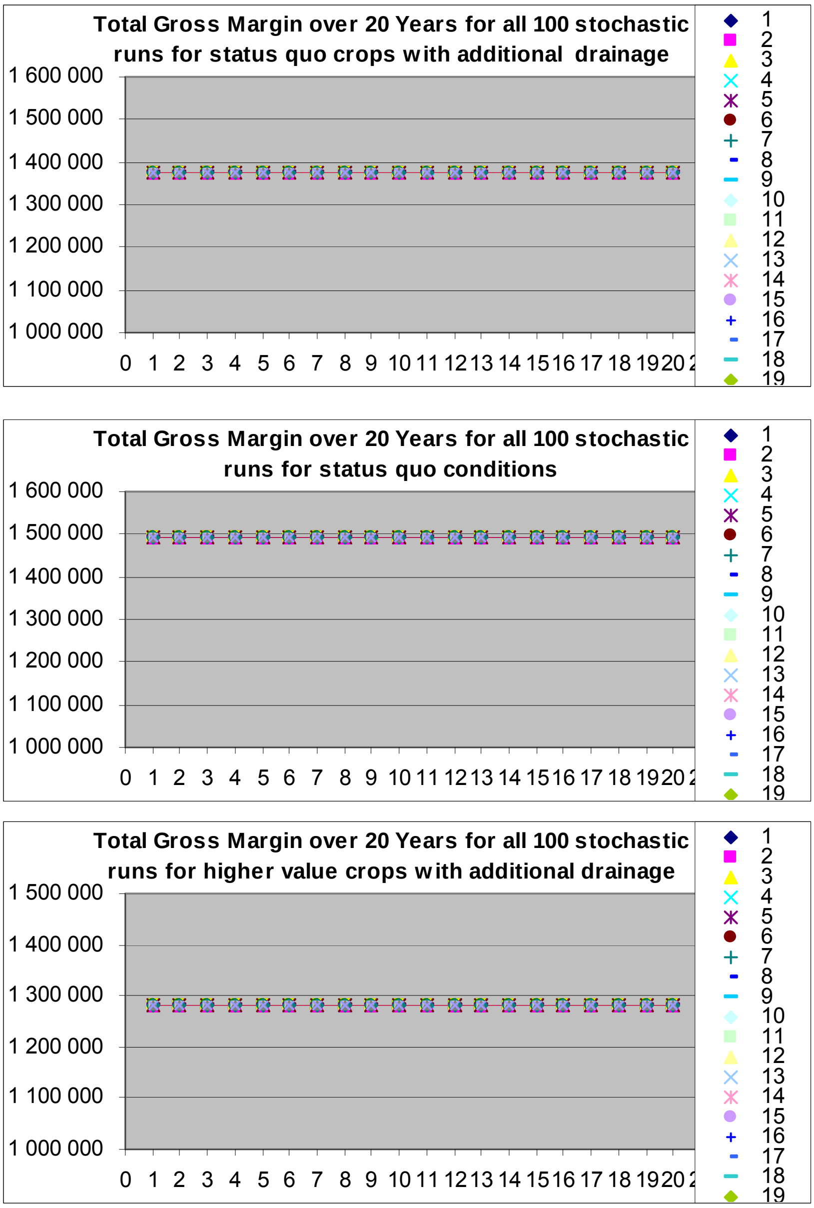

Figure 7.15. The spread of GM/ha/yr for the SQ, AD and AD+ situations modelled for 100 stochastic TDSe sequences

Table 7.46 analyses the long term cash flows of stochastic run number 80 (the sequence that most closely fits the 0.50 percentile of all GM sequences) using NPV, BCR and IRR for various discount rates and comparing the two additional drainage scenarios with the status quo conditions. Looking at Table 7.46, the results show clearly that changing crops to barley on the additional drainage has a far worse impact on the NPV that just adding the drainage on exiting crops, and the even just draining existing crops for salinity management isn't feasible due to the good quality water received via a the Orange Riet Canal and a good starting ECe value in the soil. It must however be remembered that this model only accounts for salinity management and does not tale water-logging into account.

Table 7.46. Results of additional drainage with higher value crops for the OR-WUA case study farmer

	AD minus SQ		AD+ minus SQ	
Discount rate	**NPV**	**B:C Ratio**	**NPV**	**B:C Ratio**
0.00%	-2 577 246	-14.88	-4 418 274	-3.56
5.00%	-1 615 583	-7.86	-2 708 121	-3.10
6.00%	-1 490 944	-7.09	-2 487 004	-3.01
17.25%	-758 522	-3.07	-1 194 771	-2.17
IRR	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Results in Table 7.46, show that with or without including higher value crops with additional drainage that even at a 0% discount rate the NPV of the change in production practice over 20 years cannot exceed the costs to initial the drainage installed. Costs exceed the benefits at all discount rates (B:C ratio <1) and an IRR cannot be calculated.

It is therefore not feasible for the O-R case study farmer to install drainage for salinity control alone.

A.5.5 ECONOMIC IMPACTS

As the O-R case study farm wants to fund his drainage himself, no public funds would be required and thus no direct economic costs. The use of labour and contractors to install the drains can provide a direct injection into the economy. Higher returns from the land from draining and planting higher value crops will also have positive impacts in the economy through increased spending and tax revenue, however if a bad financial decision is made and the capital spent on the drainage does not improve the financial position of the farmer then there will be a direct loss to the economy, although drainage does improve the long term sustainability of the resource base, possibly justifying spending capital for tax management purposes.

Results from the analysis of the O-R case study farms financial situation show *inter alia* that to breakeven with lucerne a very small grant per ha is required, which might not justify the transactions costs of the O-R case study farm applying for the loan, indicating that where small grants may be possibly required for the improvement of the economy, that those farmers may not use the opportunity if presented due to the transactions cost involved. This is a factor that could negatively impact in small farmers.

APPENDIX 6. LOWER-ORANGE CASE STUDY FARM RESULTS

This section lists the farm level drainage feasibility analysis model results for the LO-CSF under the following main headings; Direct profitability -, Bank repayment ability -, Financial analysis - and Stochastic analysis model results, ending off with and Economic interpretation of the results.

A.6.1 DIRECT PROFITABILITY MODEL RESULTS

Drainage costs are calculated in Table 7.47 for the LO-CSF's proposed additional drainage. The 58 hectares required to drain at a cost of R28 000 per ha will cost a total of R1 624 000 which the LO-CSF will have to repay at a quarterly rate of R 66 087.

Table 7.47. Drainage costs for the LO-AREA case study farm of the LO-CSF

		LO-CSF
Hectares to drain	Ha	**58**
Average clay %	%	**20%**
Drainage Cost	/ha	**R 28 000**
Grant	%	**0%**
Value of grant	/ha	**R 0**
Total loan	/farm	**R 1 624 000**
Loan Term	years	**20**
Interest rate *(Subsidised)*	%	**15.50%**
Payments /year	terms	**4**
Repayments	/term	R -66 087
Hectares irrigable	Ha	74
Percentage to drain	%	78%
Increase in value of land	/ha	**R 4 000**
Increase in value of land	/farm	**R 232 000**

Table 7.48 is the simple rate of return calculated for the main crops and cropping combinations planted on the LO-CSF's farm, with maize added as a potential crop and for comparison. The simple rate of return for additional yields from the combination of crops when including drainage is 1.52% amounting to increased returns of R 426 per hectare. When however accounting for the costs of the drainage installation (i.e. R 4 598 / ha per year for 20 years) none of the crops produce a positive direct profitability of increased earnings, indicating that although drainage increases the rate of return, the increased profits do not cover the costs of the drainage investment at an ECe value of 200 mS/m.

The reason for calculating the ROR on increased earnings less drainage costs is to evaluate whether a farmer will at least be at the same level of immediate welfare with drainage to pay off versus carrying on without drainage. All results in Table 7.48 show that the increased GM returns from drainage are not sufficient to cover the costs of drainage.

At the bottom of the table are the breakeven loan repayments that the farmer can afford to maintain the same level of returns for each crop and cropping combination as without drainage. This is then re-calculated as the maximum loan amount that the farmer can afford for drainage per hectare. Subtracting this amount from the actual costs of drainage, leaves the amount of grant required for the farmer to breakeven. The most feasible crop to drain on a per hectare basis for the LO-CSF would be vineyards.

Table 7.48. The calculation of the simple rate of return (ROR) for the LO-CSF's farm using irrigation water EC data

R =	Simple rate of return = (I - D) / O		**1.52%**			ECe (mS/m)	**200**
I =	Average Annual After tax earnings		R 426				
D =	Annual Average depreciation of the investment		R 0	*Last a lifetime if properly maintained*			
O =	Capital Outlay Required		R 28 000	*Subtract from taxable income*			
		Unit					
O =	Drainage costs	R/ha	R 28 000				
	Interest rate	*%/yr*	15.5%				
	Term	*Yr*	20				
	Capital repayment costs	R/ha/yr	R 4 598	5.0	20.4	21.9	
	Additional maintenance costs	R/ha	R 280	1%	of capital cost per year		
	Water & Electricity costs	R/mm/ha	0.68	0.49	**0%**	**Chose crop**	
	Crops to be planted on drained soils		**Maize**	**Cotton**	**Lucerne**	**Vineyards**	
	Threshold	mS/m	170	770	200	150	
	Gradient	%/mS/m	0.12	0.052	0.073	0.096	
	Pre-drain Yield	ton/ha	**13.5**	**5.0**	**20.4**	**21.9**	
	After-drain Yield (Max yield)	ton/ha	14.0	5.0	20.4	23.0	
	Crop Water Use	mm/ha	1022	1027	1576	1443	
	Leaching required to achieve max yield	%	**10%**	**5%**	**10%**	**10%**	
	Crop Price (R/ton)	R/ton	832	3 016	552	900	
	Pre-drain Gross income	R/ha	11 231	15 079	11 255	19 706	
	After-drain Gross income	R/ha	11 651	15 079	11 255	20 700	
	Pre-drain Production costs - ex harvest (R/ha)	R/ha	6 229	10 574	4 175	10 044	
	Harvesting costs (R/ton)	R/ton	72	280	44	11	
	Pre-drain Production costs - inc. harvest (R/ha)	R/ha	7 197	11 974	5 074	10 278	
	After-drain Production costs (R/ha)	R/ha	7 582	12 289	5 461	10 668	**TOTAL**
	% area planted per year	%	**0%**	**14%**	**5%**	**81%**	**100%**
	Gross Margin above specified costs pre drain	R/ha	4 034	3 105	6 181	9 428	**8 388**
	Gross Margin above specified costs after drain	R/ha	4 068	2 510	5 514	9 752	**8 534**
	Direct profitability of GMASC after drain		-529	-2 088	917	5 154	3 936
	ROR on GMASC after drainage		-1.89%	-7.46%	3.27%	18.41%	14.06%
I =	Increased earnings (change in margin)		34	-315	-387	604	**426**
	ROR on increased earnings		0.12%	-1.12%	-1.38%	2.16%	**1.52%**
	Direct profitability of increased earnings		**-4 564**	**-4 912**	**-4 984**	**-3 993**	**-4 171**
	ROR on increased earnings less drainage costs		-16.30%	-17.54%	-17.80%	-14.26%	-14.90%
	Breakeven Repayments		R 34	R -315	R -387	R 604	R 426
	Max loan		R 207	R -1 917	R -2 355	R 3 679	R 2 595
	Grant per ha required		**R 27 793**	**R 29 917**	**R 30 355**	**R 24 321**	**R 25 405**
			99%	107%	108%	87%	91%

Conducting the same basic profitability analysis but with returnflow data by Volschenk *et al.* (2005) from the farm up-gradient of the LO-CSF's farm, SMB Boerdery and assuming that this is the source of salts on the LO-CSF's farm, and substituting the average irrigation water (i.e. river) EC value of 200 mS/m with 990 mS/m the results change dramatically. The only crop that would require a grant to drain would be cotton, a 73% grant of R 20 387 per hectare. For the rest of the other crops the increased returns form drainage more than justify the costs of drainage. A ROR of 48.29 % and increased earnings of R 13 512 per hectare are achieved, but can the LO-CSF afford the R1 624 000 required to install drainage plus the R80 000 x 58 ha = R4 640 000 to re-establish the old vineyards after drainage installation?

Table 7.49. The calculation of the simple rate of return (ROR) for the LO-CSF's Farm using ECe returnflows data from Volschenk *et al.* (2005)

R =	Simple rate of return = (I - D) / O		**48.29%**			ECe (mS/m)	**990**
I =	Average Annual After tax earnings		R 13 521				
D =	Annual Average depreciation of the investment		R 0	*Last a lifetime if propperly maintained*			
O =	Capital Outlay Required		R 28 000	*Subtract from taxable income*			
		Unit					
O =	Drainage costs	R/ha	R 28 000				
	Interest rate	*%/yr*	15.5%				
	Term	*Yr*	20				
	Capital repayment costs	R/ha/yr	R 4 598	4.4	8.6	4.5	
	Additional maintenance costs	R/ha	R 280	1%	of capital cost per year		
	Water & Electricity costs	R/mm/ha	0.68	0.49	**0%**	**Chose crop**	
	Crops to be planted on drained soils		**Maize**	**Cotton**	**Lucerne**	**Vineyards**	
	Threshold	mS/m	170	770	200	150	
	Gradient	%/mS/m	0.12	0.052	0.073	0.096	
	Pre-drain Yield	ton/ha	**0.2**	**4.4**	**8.6**	**4.5**	
	After-drain Yield (Max yield)	ton/ha	14.0	5.0	20.4	23.0	
	Crop Water Use	mm/ha	1022	1027	1576	1443	
	Leaching required to achieve max yield	%	**10%**	**5%**	**10%**	**10%**	
	Crop Price (R/ton)	R/ton	832	3 016	552	900	
	Pre-drain Gross income	R/ha	186	13 354	4 764	4 008	
	After-drain Gross income	R/ha	11 651	15 079	11 255	20 700	
	Pre-drain Production costs - ex harvest (R/ha)	R/ha	6 229	10 574	4 175	10 044	
	Harvesting costs (R/ton)	R/ton	72	280	44	11	
	Pre-drain Production costs - inc. harvest (R/ha)	R/ha	6 245	11 814	4 556	10 092	
	After-drain Production costs (R/ha)	R/ha	7 582	12 289	5 461	10 668	**TOTAL**
	% area planted per year	%	**0%**	**14%**	**5%**	**81%**	**100%**
	Gross Margin above specified costs pre drain	R/ha	-6 058	1 540	209	-6 084	**-4 707**
	Gross Margin above specified costs after drain	R/ha	4 068	2 510	5 514	9 752	**8 534**
	Direct profitability of GMASC after drain		-529	-2 088	917	5 154	3 936
	ROR on GMASC after drainage		-1.89%	-7.46%	3.27%	18.41%	14.06%
I =	Increased earnings (change in margin)		10 127	1 250	5 586	16 116	**13 521**
	ROR on increased earnings		36.17%	4.46%	19.95%	57.56%	**48.29%**
	Direct profitability of increased earnings		**5 529**	**-3 347**	**988**	**11 519**	**8 924**
	ROR on increased earnings less drainage costs		19.75%	-11.96%	3.53%	41.14%	31.87%
	Breakeven Repayments		R 10 127	R 1 250	R 5 586	R 16 116	R 13 521
	Max loan		R 61 673	R 7 613	R 34 017	R 98 152	R 82 346
	Grant per ha required		**R -33 673**	R 20 387	**R -6 017**	**R -70 152**	**R -54 346**
			-120%	73%	-21%	-251%	-194%

The SMCEB model calculates for each crop a gross margin (GM) and 20 year cash flow. For a starting ECe value of 200 mS/m Table 7.50 list the crop level GM and ranks the crops in terms of direct profitability with and without drainage.

Table 7.50. A crop level GM comparison for the LO-AREA CSF with ECe = 200

	GM with leaching		GM without leaching		Change	
	R/ha	Rank	R/ha	Rank	R/ha	Rank
Barley	1 238	20	1 273	20	-34	13
Beets	6 759	10	6 785	10	-26	10
Carrots	38 280	2	32 765	3	5 515	2
Cotton	3 061	15	3 105	15	-44	17
Cucurbits	18 218	5	18 250	5	-31	11
Dry_Beans	2 545	16	2 225	17	320	8
Fruit	37 457	3	33 667	2	3 790	3
Lucerne	6 107	11	6 181	11	-74	19
Maize	4 375	14	4 034	14	341	7
Olives	9 028	9	9 078	9	-50	18
Onions	51 143	1	42 774	1	8 369	1
Pastures	1 725	19	1 800	19	-75	20
Peanuts	1 977	18	2 012	18	-35	14
Pecan_nuts	22 642	4	20 238	4	2 403	4
Potatoes	11 251	7	9 597	7	1 655	5
Soybeans	5 922	12	5 959	12	-37	16
Sunflower	2 224	17	2 249	16	-25	9
Vegetables	11 376	6	11 408	6	-32	12
Vineyards	10 362	8	9 428	8	934	6
Wheat	4 827	13	4 864	13	-37	15

Crops for which drainage will pay for itself (i.e. directly profitable) are all the crops that have a change in gross margin greater than the drainage repayment costs (i.e. R 4 598), namely Onions, Fruit, Carrots, Pecan nuts and Potatoes in order of profitability. It must however be noted that the additional costs of establishing the long term crops and changing irrigation systems would still have to be calculated.

Table 7.51 gives the price and yield sensitivity of the various crops planted by the LO-CSF. Linked to ROR is a sensitivity analysis of price versus yield with additional drainage as well as the breakeven yields of various prices (last two columns) with and without accounting for the costs of the drainage and breakeven prices for various yields (bottom row).

Table 7.51. The price:yield sensitivity analysis for crops grown by the LO-CSF

Maize			GMASC-Drainage			
R ton	10.0	12	14	16	BE	BE+D
650	R -6 085	R -4 928	R -3 772	R -2 615	11.97	20.52
900	R -3 585	R -1 928	R -272	R 1 385	8.36	14.33
1150	R -1 085	R 1 072	R 3 228	R 5 385	6.42	11.01
1400	R 1 415	R 4 072	R 6 728	R 9 385	5.21	8.93
1650	R 3 915	R 7 072	R 10 228	R 13 385	4.38	7.52
1900	R 6 415	R 10 072	R 13 728	R 17 385	3.79	6.49
BE+D	R 1 258	R 1 061	R 919	R 813		

Cotton			GMASC-Drainage			
R ton	2.0	3	4	5	BE	BE+D
2500	R -11 742	R -9 522	R -7 302	R -5 082	5.08	7.29
3000	R -10 742	R -8 022	R -5 302	R -2 582	4.14	5.95
3500	R -9 742	R -6 522	R -3 302	R -82	3.50	5.03
4000	R -8 742	R -5 022	R -1 302	R 2 418	3.03	4.35
4500	R -7 742	R -3 522	R 698	R 4 918	2.67	3.83

5000	R -6 742	R -2 022	R 2 698	R 7 418	*2.39*	*3.43*
BE+D	*R 8 371*	*R 5 674*	*R 4 326*	*R 3 516*		

Lucerne			**GMASC-Drainage**			
R ton	***15.0***	***20.0***	***18.9***	***24***	***BE***	***BE+D***
500	R -3 388	R -1 108	R -1 620	R 715	*11.50*	*22.43*
550	R -2 638	R -108	R -676	R 1 915	*10.36*	*20.21*
600	R -1 888	R 892	R 268	R 3 115	*9.43*	*18.40*
650	R -1 138	R 1 892	R 1 212	R 4 315	*8.65*	*16.88*
700	R -388	R 2 892	R 2 156	R 5 515	*7.99*	*15.59*
750	R 362	R 3 892	R 3 100	R 6 715	*7.43*	*14.49*
BE+D	*R 726*	*R 555*	*R 586*	*R 470*		

Vineyards			**GMASC-Drainage**			
R ton	***10.0***	***15.0***	***20.0***	***25.0***	***BE***	***BE+D***
900	R -7 103	R -2 657	R 1 790	R 6 236	*12.39*	*17.99*
990	R -6 203	R -1 307	R 3 590	R 8 486	*11.25*	*16.33*
1089	R -5 213	R 178	R 5 570	R 10 961	*10.22*	*14.83*
1198	R -4 124	R 1 812	R 7 748	R 13 684	*9.28*	*13.47*
1318	R -2 927	R 3 608	R 10 143	R 16 678	*8.43*	*12.24*
1449	R -1 609	R 5 585	R 12 779	R 19 973	*7.66*	*11.12*
BE+D	*R 1 610*	*R 1 077*	*R 811*	*R 651*		

* BE is the breakeven yield of the Status Quo at different crop prices

** BE+D is the breakeven crop price at different yields or the breakeven yield at different prices of the additional (+D) drainage scenario.

A.6.2 BANK REPAYMENT ABILITY MODEL RESULTS

The bank repayment ability model, BankMod, as set up for the LO-CSF produced the results shown in Table 7.52.

Table 7.52. The Bank repayment ability cash flow model analysis results for the LO-CSF of the Status Quo (SQ) situation versus the Additional drainage (+D) scenario

	Status Quo (SQ)	Additional drainage (+D)		SQ	+D
MIN Cash Flow	*-76 337 684*	*-1 274 689*	*Net Present Value (NPV)*	*-11 426 123*	*41 872*
MAX Cash Flow	*-370 892*	*4 569 195*	*Internal Rate of Return (IRR)*	*n/a*	*n/a*

Interest rates | Total value of intermediate / loose assets R 671 800
+ve 1% | Annual capital cost replacement R 72 000
-ve 15% | Annual discount rate 16%
Monthly discount rate 1.33%

	Income Streams	Less: Direct Costs	Less: Overheads / Indirect Costs	Cash Flow	Bank Interest	Less: depreciation on loose assets	Value of movable assets	= Surplus before tax	NPV
	YEAR 1	YEAR 1	YEAR 1	STARTING	YEAR 1	10%			
SQ	545 989	-614 124	-425 004	-334 663	-96 494	-64 185	675 498	-3 916 077	-11 426 123
+D	1 531 800	-812 245	-425 004	-334 663	-81 961	-64 185	675 498	161 364	541 872

The Net Present Value (NPV) of the surpluses over 20 years equals the amount of Capital Debt that the farmer can repay, thus the farmers Repayment Ability. The Repayment Ability for the LO-CSF with drainage installed is therefore R 541 872. This is the maximum amount of debt that the bank will allow the LO-CSF. As the LO-CSF already loans R334 000 for production inputs from the bank and GWK, he will only be allowed to loan up to R220 000 to install drainage. This is far short of the R 1 624 000 calculated to drain the required 56 hectares at R 28 000 (see Table 7.47).

With drainage, he LO-CSF's maximum negative cash flow value is -R 370 892, so he will therefore have to make provision for an additional R 40 000 overdraft at the appropriate time over and above the R334 000 he has already made provision for. Without lending the LO-CSF money to install drainage the bank stands the very real risk of loosing R334 000 already leant to the LO-CSF as is evident in Figure 7.16 of when continuing at the status quo (SQ) situation .

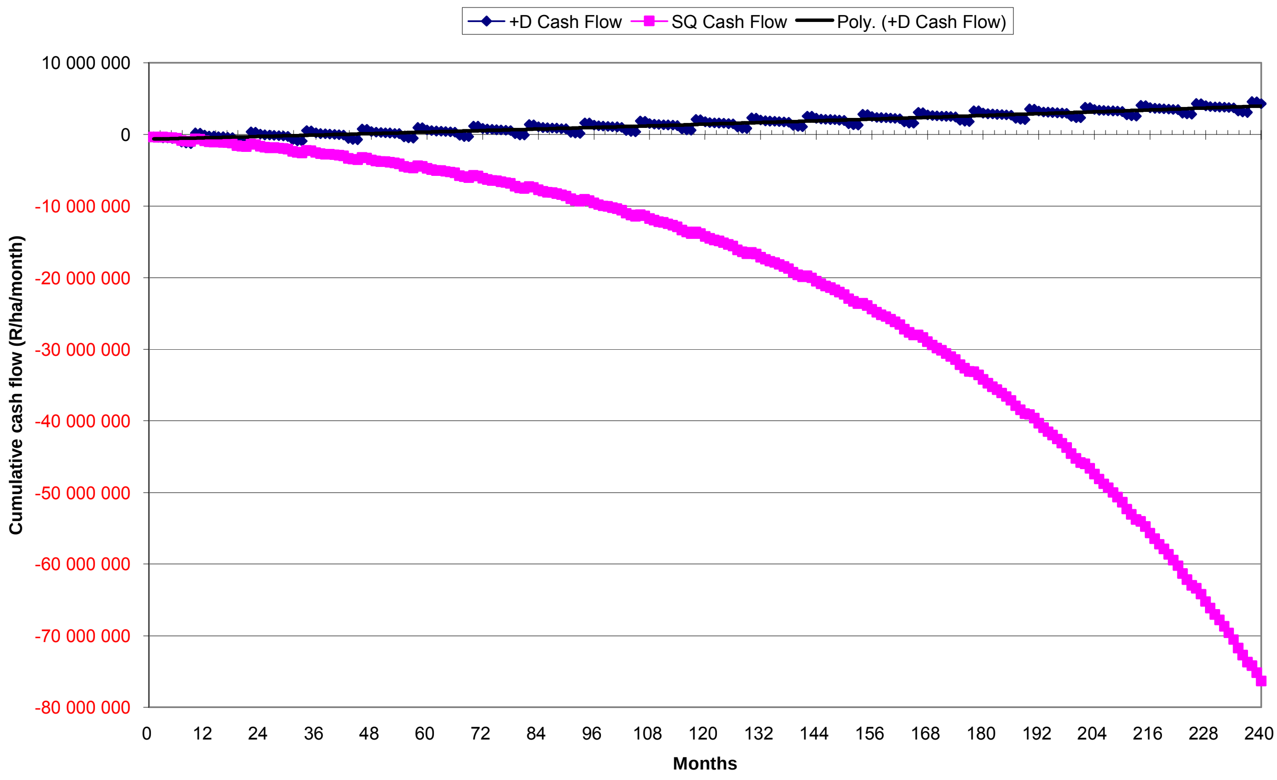

Figure 7.16. Cumulative cash flow (R/ha/yr) of the status quo (SQ) versus the additional drainage scenario (+D) over 20 years for the LO-Area CSF

A.6.3 FINANCIAL ANALYSIS RESULTS

In this section, the results for the LO-CSF of the two versions of the financial analysis model are discussed;

- the CEB based model, SMCEBs, in which self simulated soil salinisation values / sequences / trends are inputted, reports results as NPV, IRR and B:C ratios for different levels of farm financial analysis (GM, NFP and FP levels), and
- the financial analysis model, FinAnalysis, reports balance sheet, income statement and cash-flow results for the LO-CSF

A.6.3.1 SMCEBs model results for the LO-CSF

The reason for including the SMCEBs model is to have a financial analysis model for which you can simulate your own progression of ECe over 20 years. Table 7.11 is a theoretical simulation of ECe if the LO-CSF doesn't drain (the NO drainage line where ECe progressively gets worse), versus the theoretical improvement with drainage (the WITH drainage line where ECe improves dramatically in the first few years as salts get leached out, and then flattens out to equilibrium conditions with the irrigation water salinity).

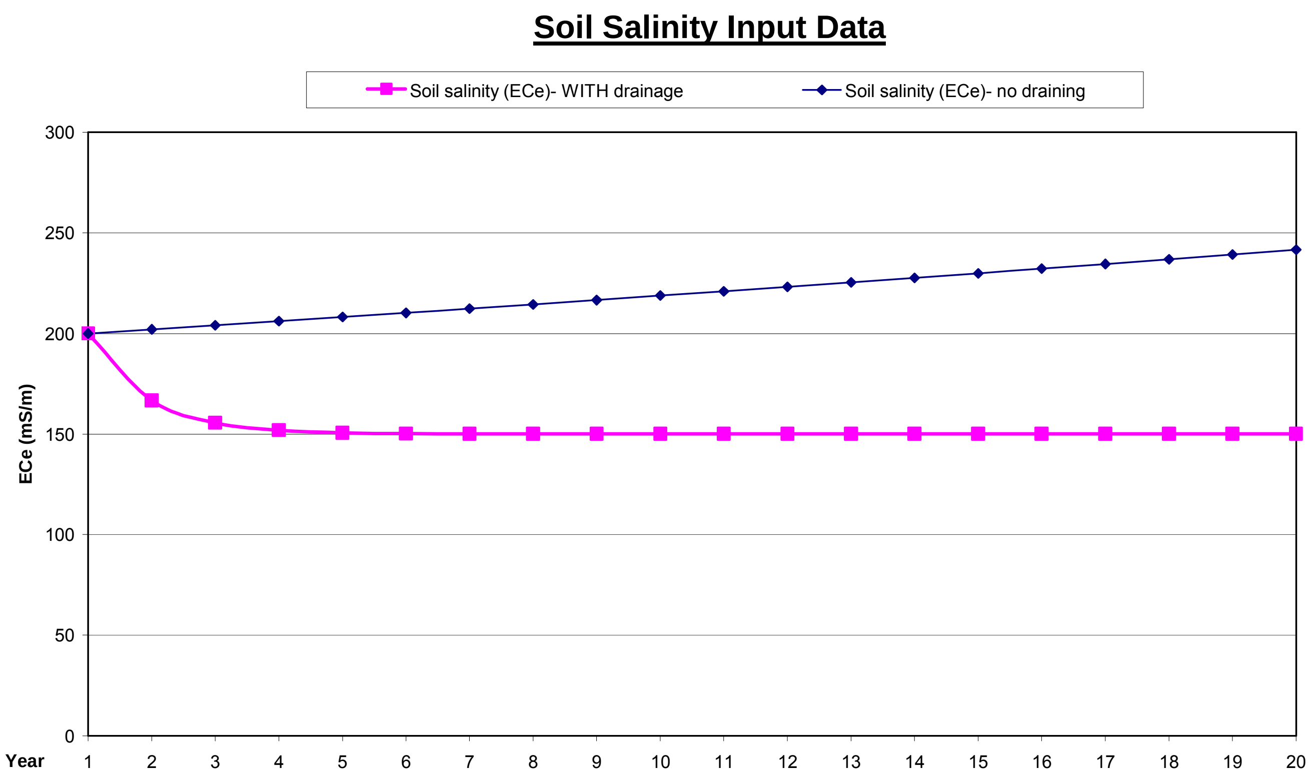

Figure 7.17. Simulated ECe data for 20 years for input into the SMCEBs model with starting ECe 200 mS/m

The other reason for the SMCEBs model is to further the direct profitability models to whole farm level, as well as to expand the level of financial analysis from gross margin (GM) level to include fixed costs and calculate the net farm income (NFI) and also to bring in capital costs to calculate the Farm Profit (FP); and tax provision and household expenses to calculate Net worth (NW) as appear in Table 7.53.

Table 7.53. The SMCEBs cash flow model results (R/ farm) for the LO-CSF

Total Income	no drains				1 411 799
	with drains				2 504 700
Total Var Costs	no drains				758 748
	with drains				1 256 313
Gross Margin	no drains	**GM**			653 050
	with drains	**GM+**			1 248 387
				Difference	*595 336*
		58	ha's drained		
Fixed Costs	no drains	<u>cost/ha</u>	<u>*Interest rate*</u>	<u>*Payment R/yr*</u>	**425 000**
	with drains	**28 000**	**15.50%**	R -266 659	425 000
Net Farm Income	no drains	**NFI**			228 050
	with drains	**NFI+**		***1 624 000***	823 387
				Difference	*595 336*
Capital redemption					
Remuneration to hired management			**2750**	x 12	33 000

Rentals					0
Interest on Capital	no drains				0
	with drains				182 644
Farm Profit	no drains	**FP**			195 050
	with drains	**FP+**			607 743
				Difference	*412 692*
+Non farm income			0		0.00
- Capital loss			0	deduct for x yrs	0.00
- Income tax provision			30%	0	0
- Private & household expenses			0	X 12	0
Net Worth	no drains	**NW**			195 050
	with drains	**NW+**			607 743
				Difference	*412 692*

The analysis of the results of Table 7.53 in Table 7.54 take the financial analysis further, from NFI level to Farm Profit (FP) level where the interest component of additional drainage is also subtracted. At Gross Margin (GM) level additional drainage (GM+) out performs the status quo (GM) producing a NPV of R 4 143 688 at a 17% discount rate. At NFI level, the costs of capital is included and the NFI+ is lower than the status quo (NFI) at R 363 853 versus R1 139 757 at 17%. The IRR of the NFI+ is 23% and the benefit cost ration 1.216:1.

At Farm Profit (FP) level where remuneration to management and interest on capital is included, the FP+ IRR is only 3% yielding a negative NPV at 17% discount rate.

Table 7.54 The SMCEBs cash flow model analysis results (R/farm) for the LO-CSF

						Year 1
GM Cash Flow				no drains	**GM**	637 342
				with drains	**GM+**	691 443
			NPV	**B:C ratio (:1)**	*Difference*	*54 101*
no drains	**GM**	0%	12 365 018	1.815	***GM end value***	***GM cumulative***
IRR	***#DIV/0!****	10%	5 315 933	1.823	**12 365 018**	637 342
		17%	3 531 558	1.827	***GM+ end value***	***GM+ cumulative***
with drains	**GM+**	0%	14 882 326	1.970	**14 882 326**	691 443
IRR	***#DIV/0!***	10%	6 297 166	1.964	***Difference***	***Difference cumulative***
		17%	4 143 688	1.960	***2 517 308***	*54 101*
						Year 1
NFI Cash Flow				no drains	**NFI**	212 342
				with drains	**NFI+**	-1 357 557
			NPV	**B:C ratio (:1)**	*Difference*	*-1 569 899*
no drains	**NFI**	0%	3 865 018	1.163	***NFI end value***	***NFI cumulative***
IRR	***#DIV/0!****	10%	1 697 668	1.169	**3 865 018**	212 342
		17%	1 139 757	1.171	***NFI+ end value***	***NFI+ cumulative***
with drains	**NFI+**	0%	4 758 326	1.268	**4 758 326**	-1 357 557
IRR	***23%***	10%	1 202 538	1.264	***Difference***	***Difference cumulative***
		17%	363 853	1.261	***893 308***	*-1 569 899*
						Year 1
FP Cash Flow				no drains	**FP**	179 342

				with drains	**FP+**	-1 573 201
			NPV	**B:C ratio (:1)**	*Difference*	*-1 752 543*
no drains	**FP**	0%	3 205 018	1.163	***FP end value***	***FP Cumulative***
IRR	***#DIV/0!****	10%	1 416 721	1.169	**3 205 018**	179 342
		17%	954 040	1.171	***FP+ end value***	***FP+ Cumulative***
with drains	**FP+**	0%	445 440	1.073	**445 440**	-1 573 201
IRR	***3%***	10%	-633 363	1.070	***Difference end value***	***Difference***
		17%	-849 743	1.068	***-2 759 577***	*-1 752 543*

* the #DIV/0! results are not faults, but a negative cash flow sequence for which an IRR cannot be calculated

Figure 7.18 summarises the various levels of cash flow discussed above. The LO-CSF's cumulative farm profit after paying off drainage only breaks even after 16 years. It must however be noted that this analysis is run at ECe levels of only 200mS/m.

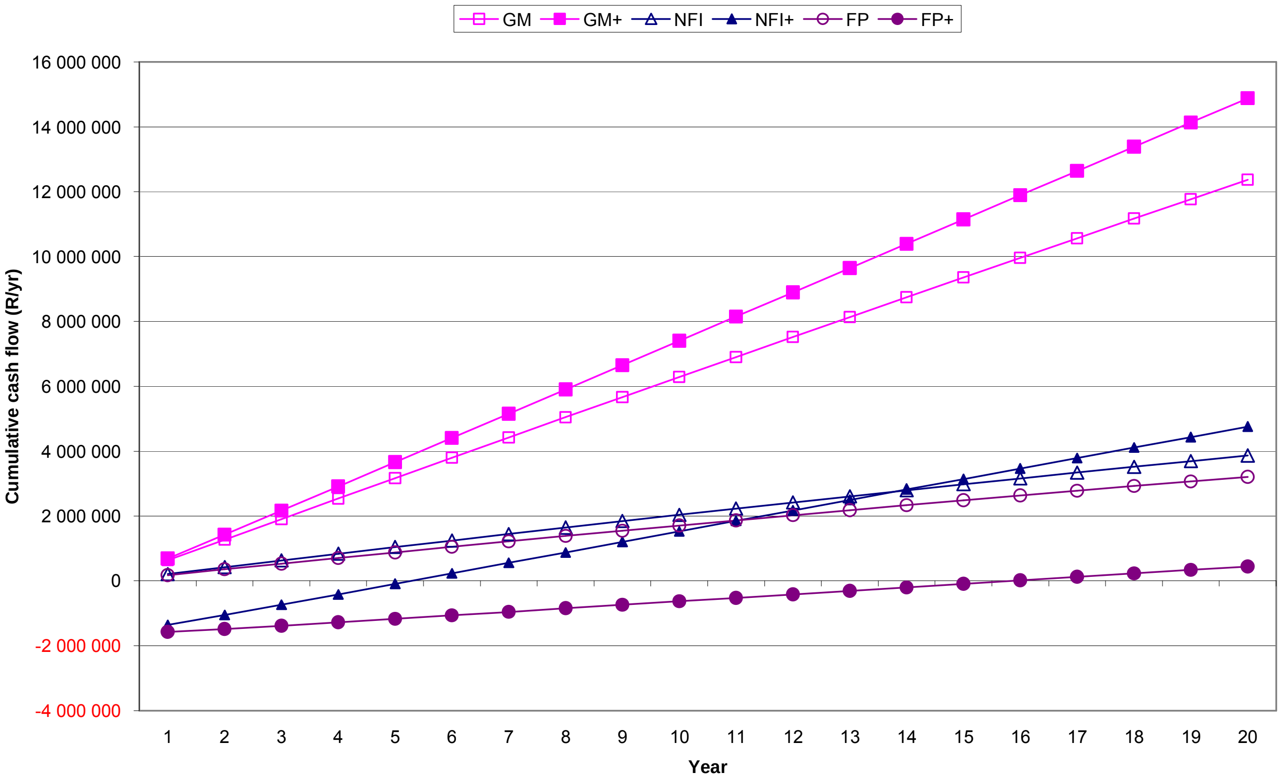

Figure 7.18. The cumulative cash flows (R/yr) comparing the status quo with additional drainage scenarios with starting ECe = 200 mS/m

A.6.3.2 Financial analysis model results

With the financial analysis data collect for the LO-CSF, the income statement, balance sheet and cash flows are compiled. Based on drainage requirements and costs the loan repayment schedule divided up into the interest and capital components is given for the LO-CSFs additional 58ha at R28000 per hectare in Table 7.55. The annual repayment at a 15.5% interest rate for the loan is R266 659, of which the average capital repayment (principal) is R81 200 per year and the average interest repayment (cost of capital) is R182 644 per year. These average values are used in the balance sheet and income statements while the actual repayment schedule is used in the long term cash flow statements.

Table 7.55. The loan repayment sequence (R) for the LO-CSF, divided up into capital and interest components

Total Loan	**1 624 000**			Hectares to drain (ha)	**58**
Deposit	**-**	**GRANT / Farmers contribution**		Average clay (%)	25%
Principal	**1 624 000**	**/ year**	**/ month**	Drainage Cost (R/ha)	**R 28 000**
Interest	**15.50%**	3.88%	1.29%	Value of grant (R/ha)	**0%**
Years	**20**	80	240		
Payments/yr	1	**4**	12		
Payment	**266 659**	**66 087**	**21 987**		

Mnth	***Still owe***	***Interest***	***Capital***	***Total cost***	***Compounded monthly (12 payments per year)***		
Totals		***3 652 885***	***1 624 000***	***5 276 885***	***Year***	***Interest***	***Capital***
1	1 624 000	20 977	1 010		1	250 820	13 024
2	1 622 990	20 964	1 023		2	248 652	15 192
3	1 621 966	20 950	1 037		3	246 123	17 722
4	1 620 930	20 937	1 050		4	243 172	20 672
5	1 619 880	20 923	1 064		5	239 730	24 114
6	1 618 816	20 910	1 077		6	235 715	28 129
7	1 617 739	20 896	1 091		7	231 031	32 813
8	1 616 647	20 882	1 105		8	225 568	38 276
9	1 615 542	20 867	1 120		9	219 195	44 649
10	1 614 423	20 853	1 134		10	211 761	52 083
11	1 613 288	20 838	1 149		11	203 089	60 755
12	1 612 140	20 823	1 164		12	192 973	70 871
13	1 610 976	20 808	1 179		13	181 173	82 671
14	1 609 798	20 793	1 194		14	167 409	96 436
15	1 608 604	20 778	1 209		15	151 352	112 492
16	1 607 395	20 762	1 225		16	132 622	131 222
17	1 606 170	20 746	1 241		17	110 774	153 070
18	1 604 929	20 730	1 257		18	85 288	178 556
…	…	…	…		19	55 558	208 286
238	64 293	830	21 157		20	20 879	242 966
239	43 136	557	21 430		TOTAL	**3 652 885**	**1 624 000**
240	21 707	280	21 707		AVERAGE	**182 644**	**81 200**

The balance sheet for LO case study farm in Table 7.56 comparing the farm business with and without drainage is only slightly changed by the addition of the drainage loan to the long term liabilities with a subsequent increase in the current liabilities loan repayments. On the assets side the value of fixed improvements are not increased by the full cost of the drainage, but only by a mere R4 000/ha. Growth in net worth is only R173 722 with drains.

Looking at the income statement in Table 7.57, total sales (and also GPV) is only increased by R27 075 by installing drainage, enough to only pay one months repayments for the drainage loan. Total production costs decrease by just under R90 000, relating to a change in Net Farm Income (NFI) of just over R110 000. Adding the interest costs to NFI the gap between the *status quo* (SQ) and AD (additional drainage) is increased to a change in Net Farm Profit (NFP) of a negative R58 000. The capital appreciation of the value of the farm brought about by the drainage inverts the gap between SQ and AD so that with additional drainage the farm Growth Net Worth (NW) is just over R170 000.

Table 7.56. Balance sheet (R/farm) for the the LO-CSF

Balance sheet for	LO-CSF				28-Feb-07
LIABILITIES	*Without Drainage*	*With Drainage*	**ASSETS**	*Without Drainage*	*With Drainage*
Current Liabilities			**Current assets**		
Banks	219 844	219 844	Cash on hand / in bank	0	0
Cooperatives	0	0	Debtors	0	1 624 000
Creditors	0	0	Prepaid expenses	0	0
Income tax	0	0	Life insurance	0	0
Bills payable	0	0	Negotiable securities	0	0
Current portion of long tern liabilities	0	0	Stock:	0	0
Term loans	0	0	*Crops and crop products*	0	0
Instalment sale payment	0	0	*Fruit products*	0	0
Lease instalments	0	0	*Production inputs*	0	0
Bond repayments	0	0	*Marketable livestock*	42 000	42 000
Long-term loans	0	0	Other	0	0
Other loans	0	0	Short-term investment	0	0
Other	0	0	*Rotating fund*	0	0
	0	0	*Co-op Shares*	151 250	151 250
Total current liabilities	**219 844**	**219 844**	**Total current assets**	**193 250**	**1 817 250**
Medium-term liabilities			**Medium-term assets**		
Term loans	82 036	82 036	Breeding stock	144 000	144 000
Instalment sale credit	0	0	Vehicles, machinery & equipment	671 800	671 800
Leases	430 769	430 769	Other: Office furniture	0	0
Other	0	0	Other	0	0
Total medium-term liabilities	**512 806**	**512 806**	**Total medium-term assets**	**815 800**	**815 800**
Long term liabilities			**Fixed assets**		
Bonds	0	0	Fixed improvements	1 985 000	1 985 000
Long-term loans	1 900 000	1 900 000	Land	3 771 000	3 771 000
Other	0	0	Other	0	0
Drainage loan	0	1 624 000	Increase in drained land value	0	232 000
	0	0		0	0
Total long-term liabilities	**1 900 000**	**3 524 000**	**Total Fixed assets**	**5 756 000**	**5 988 000**
Total Liabilities	2 632 650	4 256 650			
Net worth (from income statement)	-16 256	157 467			
Total Liabilities + Net Worth	**2 616 394**	**4 414 117**	**Total Assets**	**6 765 050**	**8 621 050**
			Value of hired land	0	0
Growth in net worth with drains	**173 722**		**Total capital employed**	**6 765 050**	**8 621 050**

Compiled by R.J. Armour, WRC Drainage Consultancy Project — Adapted from Finance & Farmers, Standard Bank (2005)

Table 7.57. Income statement (R/farm) for the LO-CSF

Income statement for the period	May 2005-April 2006	LO-CSF				
Description		**Livestock**	**Crops**		***TOTAL***	
		Livestock	*Without Drainage*	*With Drainage*	***Without Drainage***	***With Drainage***
Sales	Cash	0	1 430 823	1 458 498	**1 430 823**	**1 458 498**
	Credit	0	0	0	**0**	**0**
	Account	0	0	0	**0**	**0**
	Transport and contract work	0	0	0	**0**	**0**
	Other	0	0	0	**0**	**0**
TOTAL Sales		0	1 430 823	1 458 498	**1 430 823**	**1 458 498**
Consumption	Household	0	0	0	**0**	**0**
	Labour	0	0	0	**0**	**0**
	Internal		0	0	**0**	**0**
TOTAL consumption		0	0	0	**0**	**0**
Stock adjustment						
	Closing stock	186 000	0	0	**186 000**	**186 000**
Less:	Opening stock	186 000	0	0	**186 000**	**186 000**
Less:	Purchases	0	0	0	**0**	**0**
TOTAL stock adjustment		0	0	0	**0**	**0**
TOTAL GROSS PRODUCTION VALUE	**(GPV)**	**0**	**1 430 823**	**1 458 498**	**1 430 823**	**1 458 498**
Less: Production, marketing and administration costs						
Allocatable Production inputs	Seed	0	158 053	158 053	**158 053**	**158 053**
	Fertiliser	0	69 022	69 022	**69 022**	**69 022**
	Herbicides	0	140 052	140 052	**140 052**	**140 052**
	Pesticides	0	13 940	13 940	**13 940**	**13 940**
	Licences and insurance	0	97 283	97 283	**97 283**	**97 283**
	Fuel & Lubricants	0	14 147	14 147	**14 147**	**14 147**
	Repairs machinery and equipment	0	20 789	20 789	**20 789**	**20 789**
	Labour (temp)	0	98 239	98 239	**98 239**	**98 239**
	Water?	0	36 865	36 865	**36 865**	**36 865**
	Electricity	0	71 324	71 324	**71 324**	**71 324**
	Packaging, storage & Harvesting	0	28 697	29 018	**28 697**	**29 018**
	Stock feed	0	0	0	**0**	**0**
	Supplies	0	0	0	**0**	**0**
	Other	0	0	0	**0**	**0**
Labour costs (permanent)	Wages	0	349 960	349 960	**349 960**	**349 960**
	Wages owing	0	0	0	**0**	**0**
	Farm products consumed	0	0	0	**0**	**0**
	Other	0	0	0	**0**	**0**
Depreciation	Fixed improvements	0	0	0	**0**	**0**
	Machinery and equipment	0	0	0	**0**	**0**
Repair and maintenance	Fixed improvements	0	0	0	**0**	**0**
	Machinery & equipment	0	0	0	**0**	**0**
Other expenses	Veterinary, medicine & AI	0	0	0	**0**	**0**
	Transport and contract work	0	0	0	**0**	**0**
	Marketing costs	0	0	0	**0**	**0**
	Packaging and storage	0	0	0	**0**	**0**
	Licences and insurance	0	38 100	38 100	**38 100**	**38 100**
	Electricity	0	21 600	21 600	**21 600**	**21 600**
	Water	0	129 375	45 600	**129 375**	**45 600**
	Telephone, postage and stationery	0	24 600	24 600	**24 600**	**24 600**
	Fuel & Lubricants	0	90 717	90 717	**90 717**	**90 717**
	Other	0	18 800	18 800	**18 800**	**18 800**
Total Production, Marketing and admin costs		0	1 421 564	1 338 110	**1 421 564**	**1 338 110**
NET FARM INCOME	**(NFI)**	0	9 259	120 388	**9 259**	**120 388**
Less: Compulsory capital redemption						
	Interest (drainage Loan)	0	0	182 644	**0**	**182 644**
	Production loan / overdraft ???	0	25 515	12 277	**25 515**	**12 277**
	Rentals	0	0	0	**0**	**0**
	Share-cropping	0	0	0	**0**	**0**
Total Compulsory capital redemption		0	25 515	194 921	**25 515**	**194 921**
FARM PROFIT	**(NFP)**	**0**	-16 256	-74 533	**-16 256**	**-74 533**
Plus:	Non-farming income	0	0	0	**0**	**0**
	Capital appreciation	0	0	232 000	**0**	**232 000**
	Capital profits	0	0	0	**0**	**0**
	Own-capital inflow	0	0	0	**0**	**0**
Less:	Capital loss	0	0	0	**0**	**0**
	Own-capital outflow	0	0	0	**0**	**0**
	Dividends / profits	0	0	0	**0**	**0**
	Income tax provision	0	0	0	**0**	**0**
	Private & household expenses	0	0	0	**0**	**0**
	Farm products consumed	0	0	0	**0**	**0**
GROWTH IN NET WORTH	**(GNW)**	**0**	**-16 256**	**157 467**	**-16 256**	**157 467**
Reconciliation:						
Net worth - Previous balance sheet		0	-16 256	-16 256	**-16 256**	**-16 256**
Plus: Growth in net worth (with drainage from status quo)		0	-16 256	157 467	**-16 256**	**157 467**
Net worth - Present balance sheet		0	-32 511	141 211	**-32 511**	**141 211**

Compiled by R.J. Armour, WRC Drainage Consultancy Project

Adapted from Finance & Farmers, Standard Bank (2005)

A one year cash flow analysis (Table 7.58) of the LO-CSF reveals that with an opening balance of - R219 844 (sum of current liabilities) that there is a difference in the cash flow closing balance of just over R300 000 with drainage, ending with R354 926, compared to R50 4923 without.

Table 7.58. An annual cash flow statement (R/farm) for the LO-CSF

LO-CSF

Cash Flow statement for the period:	May 2005-April 2006			Without additional drainage									
	TOTAL	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Operating income													
	1 430 823			357 706			357 706			357 706			357 706
Capital income	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Breeding stock	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Machinery and equipment	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Non-farm income	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Total income	**1 430 823**	**0**	**0**	**357 706**	**0**	**0**	**357 706**	**0**	**0**	**357 706**	**0**	**0**	**357 706**
Operating expenditure													
Directly allocatable inputs													
Seed	**158 053**	13 171	13 171	13 171	13 171	13 171	13 171	13 171	13 171	13 171	13 171	13 171	13 171
Fertiliser	**69 022**	5 752	5 752	5 752	5 752	5 752	5 752	5 752	5 752	5 752	5 752	5 752	5 752
Herbicides	**140 052**	11 671	11 671	11 671	11 671	11 671	11 671	11 671	11 671	11 671	11 671	11 671	11 671
Pesticides	**13 940**	1 162	1 162	1 162	1 162	1 162	1 162	1 162	1 162	1 162	1 162	1 162	1 162
Licences and insurance	**97 283**	8 107	8 107	8 107	8 107	8 107	8 107	8 107	8 107	8 107	8 107	8 107	8 107
Fuel & Lubricants	**14 147**	1 179	1 179	1 179	1 179	1 179	1 179	1 179	1 179	1 179	1 179	1 179	1 179
Repairs machinery and equipment	**20 789**	1 732	1 732	1 732	1 732	1 732	1 732	1 732	1 732	1 732	1 732	1 732	1 732
Labour	**98 239**	8 187	8 187	8 187	8 187	8 187	8 187	8 187	8 187	8 187	8 187	8 187	8 187
Water?	**36 865**	3 072	3 072	3 072	3 072	3 072	3 072	3 072	3 072	3 072	3 072	3 072	3 072
Electricity	**71 324**	5 944	5 944	5 944	5 944	5 944	5 944	5 944	5 944	5 944	5 944	5 944	5 944
Packaging and storage (& Harvesting)	**28 697**	2 391	2 391	2 391	2 391	2 391	2 391	2 391	2 391	2 391	2 391	2 391	2 391
Transport and contract work	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Marketing costs	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Purchased stock feed	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Veterinary, medicine & AI	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Unallocatable direct operating costs													
Repairs fto buildings and improvements	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Income tax	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Telephone, postage and stationery	**24 600**	2 050	2 050	2 050	2 050	2 050	2 050	2 050	2 050	2 050	2 050	2 050	2 050
Rentals	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Salaries	**349 960**	29 163	29 163	29 163	29 163	29 163	29 163	29 163	29 163	29 163	29 163	29 163	29 163
Bank charges	**12 000**	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000
Other	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Capital expenditure													
Livestock	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Machinery and equipment	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Debt Redemption													
Capital	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Interest	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Non-farm expenditure	**0**	0	0	0	0	0	0	0	0	0	0	0	0
Total expenditure		94 581	94 581	94 581	94 581	94 581	94 581	94 581	94 581	94 581	94 581	94 581	94 581
Surplus / shortfall		-94 581	-94 581	263 125	-94 581	-94 581	263 125	-94 581	-94 581	263 125	-94 581	-94 581	263 125
Bank balance													
Opening balance	**-219 844**												
New balance		-314 425	-412 413	-153 756	-250 003	-347 292	-87 929	-183 463	-280 032	-19 940	-114 738	-210 562	50 282
Positive Interest	**5.00%**	0	0	0	0	0	0	0	0	0	0	0	210
Negative interest	**13.00%**	-3 406	-4 468	-1 666	-2 708	-3 762	-953	-1 988	-3 034	-216	-1 243	-2 281	0
Closing balance		-317 832	-416 881	-155 421	-252 711	-351 054	-88 882	-185 451	-283 065	-20 156	-115 980	-212 843	**50 492**
										603%	*increase with drains*		*354 928*

Compiled by R.J. Armour, WRC Drainage Consultancy Project

Adapted from Finance & Farmers, Standard Bank (2005)

Financial ratios in Table 7.59 indicate following:

- Solvency; a weakening net capital ratio but still above the required benchmark, and a much better leverage ratio and own capital ratio
- Liquidity; considerably improved with the installation of drainage
- Profitability; is not really applicable as you cannot compare the status quo with additional drainage. Farm profitability with drainage is very low at 1.09% and the profitability on own capital -195.65%.
- Efficiency; Capital turnover is slightly weekend, the cost ratio approaches 1 by only 0.04%, but the Debt servicing ration moves further away from 0 (from 0.018 to 0.315).

Table 7.59. The financial ratios for the LO-CSF

SOLVENCY	Status Quo	Additional drains	
Net Capital Ratio:	**2.57**	**2.03**	**:1**
Total assets	6 765 050	8 621 050	(>2)
Total Liabilities	2 632 650	4 256 650	
Leverage Ratio:	**-80.98**	**30.14**	**:1**
Total Liabilities	2 632 650	4 256 650	(<1)
Own capital (Net worth)	-32 511.30	141 211.09	
Own Capital Ratio:	**-0.00**	**0.02**	**:1**
Own capital (Net worth)	-32 511.30	141 211.09	(>0.5)
Total assets	6 765 050	8 621 050	
Buisness Growth:		**123.02**	**%**
NW with drains - NW without		173 722.40	(>inflation)
NW without		141 211.09	x 100/1

PROFITABILITY	Status Quo	Additional drains	
Farm profitability (return on assets):		**1.09**	**%**
NFI		120 388	(R / R100)
Ave. total capital employed		11 075 575	x 100/1
Profitability on own capital:		**-195.65**	**%**
Farm Profit		-74 533	(>inflation)
Average own capital		38 094	x 100/1

LIQUIDITY	Status Quo	Additional drains	
Current ratio:	**0.88**	**8.27**	**:1**
Current assest	193 250.00	1 817 250.00	(>2)
Current liabilities	219 844.44	219 844.44	
Acid test ratio:	**0.69**	**8.08**	**:1**
Current assets - stocks & supplies	151 250.00	1 775 250.00	(=1)
Current liabilities	219 844.44	219 844.44	
Intermediate ratio:	**1.38**	**3.59**	**:1**
Current + medium term assest	1 009 050.00	2 633 050.00	(>4)
Current + medium term liabilities	732 650.04	732 650.04	

EFFICIENCY	Status Quo	Additional drains	
Capital Trurnover ratio:	**0.21**	**0.17**	**:1**
Gross production value	1 430 823	1 458 498	(>>1)
Average total capital employed	6 765 050	8 621 050	
Cost ratio:	**1.01**	**1.05**	**:1**
Total expenditure	1 447 079	1 533 031	(<1)
Gross value of production	1 430 823	1 458 498	
Debt servicing ratio:	**0.018**	**0.315**	**:1**
Debt redemption (installment + interest)	25 515	458 765	(0<<)
Gross value of production	1 430 823	1 458 498	

A.6.4 STOCHASTIC ANALYSIS (BIO-PHYSICAL RISK)

As stochastic data for the Lower Orange area wasn't produced by the WRP model, the closest results to the Lower Orange area would be the Riet Scheme (Rscm) irrigation block data as it gets it irrigation water from the Orange River via the Orange Riet Canal. The same set of soils ECe values as used in the stochastic analysis for the OR-WUA CSF are therefore used for analysis on the LO-case study farmer's data.

Using the soil water qualities from **Figure 7.12** and **Figure 7.13** (OR-WUA CSF), the cropping combinations in Table 7.60 are run through the stochastic financial simulation model. SQ (Status Quo) is the cropping combination the LO-case study farmer currently plants, AD (Additional Drainage) is the same crop choice and hectarage but with the farmer selecting which crops he will plant on the additional newly drained soil, and AD+ (Additional Drainage + higher value crops) is the new (higher value) cropping composition the LO-case study farmer would like to plant once additional drainage is installed.

Table 7.60. Existing and proposed cropping data input for the LO-AREA case study farmer

	LO Farmer	Barley	Beets	Carrots	Cotton	Cucurbits	Dry_Beans	Fruit	Lucerne	Maize	Olives	Onions	Pastures	Peanuts	Pecan_nuts	Potatoes	Soybeans	Sunflower	Vegetables	Vineyards	Wheat	Total Area (ha)
Status Quo cropping composition																						
SQ	Base Case	-	-	-	8	-	-	-	3	-	-	-	-	-	-	-	-	-	-	47	-	58
SQ	Scen3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16	-	16
Additional drainage-same crops					*58ha additional*																	
AD	Base Case	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AD	Scen3	-	-	-	8	-	-	-	3	-	-	-	-	-	-	-	-	-	-	63	-	74
Additional drainage-higher value crops					*58ha additional*																	
AD+	Base Case	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AD+	Scen3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	74	-	74

The stochastically generated 100 GMs for each of the 20 years modelled for the LO-AREA case study farmer appear in Figure 7.19. The top graph shows a slightly wider spread of results as a result of not having drainage whereas the lower two graphs show a much smaller spread of GM outcomes, directly as a result of the installation of additional drainage.

The spread of annual GMs in the upper graph predominantly occurs between R1 750 000 and R1 800 000, in the middle graph (same crops but with and additional 58ha drained) the GMs predominantly occur just below R1 550 000, and in the bottom graph (all planted to vines) GMs predominantly occur just below R1 700 000.

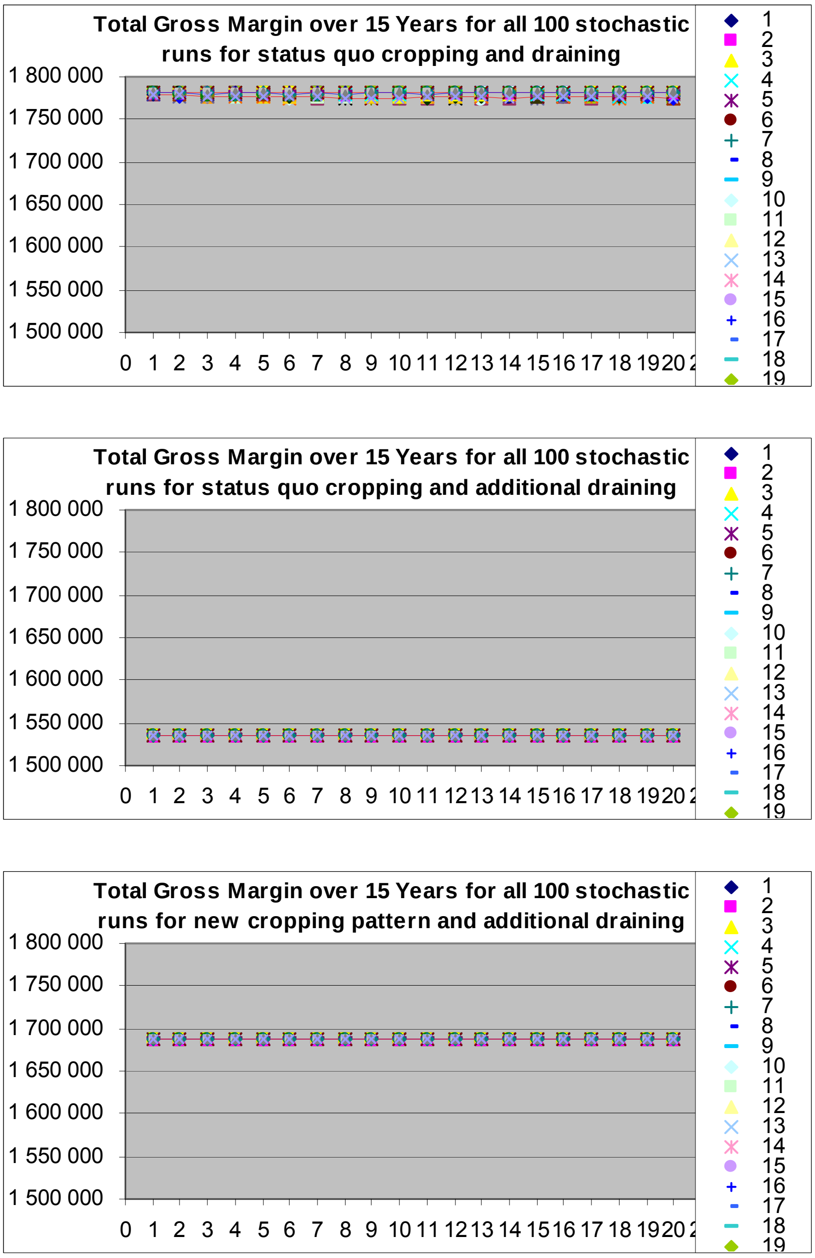

Figure 7.19. The stochastic GM (R/farm) results of the three scenarios for the LO-AREA case study farmer

The results in Figure 7.20 show the difference in the in spread of results between the 3 scenarios. Adding additional drainage to the status quo cropping choice show a sharp decline from the status quo, but selecting higher value crops makes an improvement in GM results, but not to the same level as the status quo.

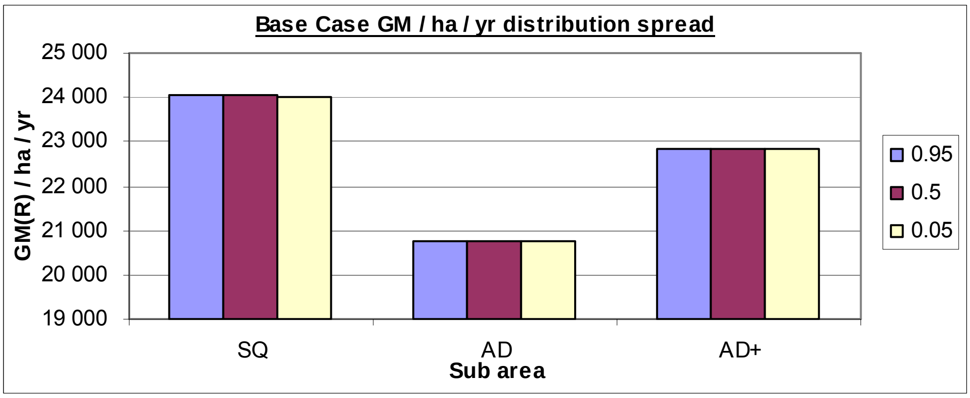

Figure 7.20. The spread of GM/ha/yr for the SQ, AD and AD+ situations modelled for 100 stochastic TDSe sequences

Table 7.61 and Table 7.62 analyse the long term cash flows of stochastic run number 80 (the sequence that most closely fits the 0.50 percentile of all GM sequences) using NPV, BCR and IRR for various discount rates, comparing the two additional drainage scenarios with the status quo conditions. Table 7.61 is compiled using Orange River water quality data from the WRPM stochastic analysis data compiled for the Riet Scheme (***Rscm***) in Viljoen *et al.* 2006, but this was unrealistic for the area as salinisation is clearly visible and in the light of the results form Volschenk *et al.* 2005. Table 7.62 was therefore compiled using the worst case WRPM data, namely the Lower Riet water quality data that will more closely match situation on the LO-case study farmer's farm.

Table 7.61. Results of additional drainage with status quo crops for the LO-AREA case study farmer using Orange River (Rscm) water quality

	AD minus SQ		AD+ minus SQ	
Discount rate	***NPV***	***B:C Ratio***	***NPV***	***B:C Ratio***
0.00%	-1 215 865	0.25	206 412	1.12
5.00%	-1 311 202	0.15	-467 168	0.70
6.00%	-1 319 170	0.14	-549 670	0.65
17.25%	-1 303 380	0.06	-966 359	0.31
IRR	#NUM!	#NUM!	1.16%	1.00

Results in Table 7.61 show that without including higher value crops with drainage that even at a 0% discount rate that the NPV of the NFI with the additional drainage minus the NFI of the Status Quo is negative with additional drainage. The benefit cost ratio are also all below 1 indicating that there is no financial benefit from draining the existing cropping combination with the good ***Rscm*** soil water quality (ECe) values.

Replacing the lower value lucerne and cotton crops with vineyards on the newly drained soils with ***RScm*** ECe values is only viable at a discount rate of up to 1.16% (=IRR). A zero discount rate gives a NPV of R 206 412.

Table 7.62 however looks at a more realistic soil water quality (ECe) situation where ***RloR*** ECe values are used, and the results are entirely different.

Table 7.62. Results of additional drainage with higher value crops for the LO-AREA case study farmer using RIoR water quality

Discount rate	AD minus SQ		AD+ minus SQ	
	NPV	B:C Ratio	NPV	B:C Ratio
0.00%	4 462 015	3.62	5 867 689	4.36
5.00%	2 105 914	2.32	2 935 018	2.81
6.00%	1 804 065	2.14	2 558 940	2.60
17.25%	91 552	1.07	416 819	1.29
IRR	18.55%	1.00	23.00%	1.00

Interpreting at Table 7.62, where a worse soil water quality scenario is used, the additional drainage on existing crops yields a positive NPV or R91 552 at the bank discount rate of 17.25%, with an IRR just above that at 18.55%. Where all the lower value crops are also replaced with vineyards on the newly drained lands, the IRR is raised to 23% and the NPV at the bank discount rate is more tan four times greater at R 416 819.

At this worse case ECe scenario results clearly show that the farmer is just able to recover the full costs of drainage without government assistance, but the difference between the bank discount rate and the IRR is small. Furthermore, this preliminary model does not make provision for the very high initial establishment costs of long term crops; it factors these costs into the full life span of the crop. Changing this is expected to also make the results less favourable.

Table 7.63 shows that without drainage (SQ) the NFI in years 1 and 4 of the first four years of the twenty year cash flow, that the LO-case study farmer would make a loss. Current losses already incurred by the farmer due to salinisation and waterlogging have given him a poor financial record and to get the high levels of financing required to replace all the vines at once would not be possible, besides would also not be practical. A phase approach over a number of years would be more realistic.

For year 1 Table 7.63 shows that additional drainage alone increased the negative SQ NFI of -R 33 308 to a positive AD NFI of R244 544, an improvement of R277 852. Changing to higher value crops further improves NFI by R57 524.

Table 7.63. The first four years of the NFI cash flows (R/farm) used to generate the results in Table 7.61 and Table 7.62 for the LO-case study farmer.

NPV, IRR & BC Analysis				LO-case study farm		
Year	0	1	2	3	4	5 - 20
SQ						
Total income		1 097 290	1 134 279	1 131 273	1 105 858	…
Total Variable costs		744 038	744 523	744 469	744 121	…
Total fixed costs		386 560	386 560	386 560	386 560	…
SQ NFI	0	-33 308	3 196	244	-24 822	…
AD						
Total income		1 378 906	1 441 041	1 458 498	1 458 498	…
Total Variable costs		747 801	748 531	748 733	748 733	…
Total fixed costs		386 560	386 560	386 560	386 560	…
AD NFI	-1 624 000	244 544	305 950	323 205	323 205	…
AD+						
Total income		1 438 467	1 511 295	1 531 800	1 531 800	…
Total Variable costs		749 839	750 684	750 921	750 921	…
Total fixed costs		386 560	386 560	386 560	386 560	…
AD+ NFI	-1 624 000	302 068	374 051	394 319	394 319	…
NFI Difference						
AD minus SQ	-1 624 000	277 852	302 754	322 961	348 027	…
AD+ minus SQ	-1 624 000	335 376	370 855	394 075	419 141	…
AD+ minus AD	0	57 524	68 101	71 114	71 114	…