



# Land-Water Linkages in Rural Watersheds Electronic Workshop 18 September – 27 October 2000

## Case Study 6

### **Economic effects of changing water quality on an irrigation scheme: a case study from South Africa**

R. Jack Armour  
Department of Agricultural Economics  
University of the Orange Free State  
PO Box 339 Bloemfontein 9300  
email: [armourj@landbou.uovs.ac.za](mailto:armourj@landbou.uovs.ac.za)

## INTRODUCTION

Irrigation agriculture as a contributor to non-point-source water pollution externalities through nutrients, salts and chemicals in return flows is a global problem and one of growing concern in South Africa. Backeberg *et al.* (1996:22), states “water quality is becoming of increasing concern to irrigation, both from a supply point of view and with respect to the environmental impacts of irrigation.”

In 1995 in South Africa alone about 110 000 ha of irrigated land was already affected by waterlogging or salinization. With Sub-Saharan Africa by far having the highest population growth rate in the world: 2.9% per annum, food shortages in this region loom in the not too distant future. Tremendous pressure is going to be placed on expanding the potentially irrigated area. This will be at a disastrous cost to the environment and hence on the sustainability of new schemes if the necessary precautions are not taken.

Seckler *et.al.*(1999) classify South Africa under category 1; i.e. countries facing "absolute water scarcity" that will not be able to meet water needs in the year 2025. Water use efficiency in irrigation agriculture will thus also become crucial as per capita demand for water increase (Basson, *et. al.*, 1997)

## THE CASE STUDY AREA

Douglas, the main town within the study area (see figure 1), is a thriving community in the rural Northern Cape based entirely on the forward and backward linkages of the irrigation agricultural industry. In 1984 the Orange-Vaal Irrigation Board (OVIB) was established to manage water allocations in the demarcated area. In the Vaal River system water usage is prioritized for industrial and residential use in Johannesburg, for mining purposes in the Free State gold-fields and for Vaalharts, the biggest irrigation scheme in South Africa.

During times of drought in the upper Vaal River catchment, water shortages in the study area thus prevailed. A particularly bad drought in 1992 led to the construction of the Louis Bosman Canal (completed in 1994) to transfer Orange River water to the Douglas weir. Together with the increased water security, farmers noticed a marked improvement in crop yields due to the improvement in water quality. The Department of Water Affairs and Forestry (DWAF) data shows clearly that water quality improved dramatically in the Douglas weir after Orange River water was pumped into the system.

The reason for the poor water quality was initially believed to be as a result of industry and mining in the upper reaches of the Vaal River. It has since been shown in various studies on the lower Vaal River (Du Plessis(1982), Moolman & Quibell (1995) and Nel (1995)) that the actual process of irrigation in the area displaces certain salts found inherently in the soil and releases sodium, chloride and other salts into the water while at the same time breaking down the physical structure of the soil. Although water quality does not actually worsen progressively over time within the study area, it is expected that the irrigability of soils can be affected. This, together with the current “price-cost squeeze” effect has led to the questioning of the long-term sustainability of current irrigation practices in the OVIB region.

Pumping costs, irrigation system capacity and limited drainage installation in the study area make farmers reluctant to “over irrigate” to leach out salts that have built up in the soils from years of irrigation. Because the river operates within a closed system all leachate that does occur, returns directly into the system exacerbating the water quality problem. The rapid fluctuation in water quality, especially in the Lower Riet River arm makes crop production most unpredictable, leading to instability in the region. This has resulted in a crop choice away from



To leach effectively, soils should have a good infiltration rate till beyond the root zone. In heavy soils and where waterlogging occurs artificial drainage is required. The heavier the soils, the more expensive the costs of installing the artificial drainage. Thus the benefits of leaching need to be quantified to be able to justify the capital expenses involved.

The seepage from leaching however flows back into the river or groundwater carrying high concentrations of salts, further degrading the water source and creating secondary costs through externalities for downstream users. The paradox however is that without leaching salts (those inherently found in soil or those deposited by irrigating with poor water quality) out of the soil, salts build up, degrading the soil to levels that can no longer support viable crop production. With leaching, downstream water is degraded rendering it less suitable for other uses, including the environment.

### **THE PROBLEM STATEMENT**

Besides the expected irrigation water price increases, without proactive management, water quality degradation will further jeopardize the sustainability of irrigation agriculture, and with its forward and backward linkages, entire rural economies supported by irrigated agriculture. To ensure the sustainability of irrigation, intensive management needs to be applied at both farm and irrigation board level to ensure water use optimization while minimizing any possible negative effect on the environment.

The problem is thus to apply models to test the outcome of alternative scenarios regarding internal management practices and external policy measures.

### **MODEL**

To address the salinity issue we have developed an optimization model, SALMOD (Salinity And Leaching Model for Optimal irrigation Development). Using the economic tools of linear programming, simulation & risk modeling techniques, the model is constructed to aid in water resource management so as to ensure the economic sustainability of irrigated agriculture experiencing river water quality problems, particularly salinity. The model is constructed to assist farmers to choose the optimal enterprise composition and adopt the best management practices (BMP). With SALMOD all management options and possible crops are weighed up against each other to find the profit maximizing combination of crops and management options under different water quality situations.

### **CONCLUSION**

On successful completion of the model, the ultimate aim is that it can be used in the sustainable expansion of irrigation agriculture in Sub-Saharan Africa, as well as to increase the level of sustainability of existing schemes. This will only be achieved by accounting for the economic, social and environmental effects of irrigated agriculture.

Potentially useful data currently generated by SALMOD for use in environmental and social impact assessment is the volume of salt loaded return-flows that either leach into groundwater aquifers or are returned into the river system as a “diffuse pollution source”. The model gives a good indication of a farmer’s specific contribution to the diffuse or non-point source pollution problem. The economic effects of constraining return-flow and the effects of water pricing policy on the volume of return flows can also be determined. Irrigation waters of different qualities are essentially different commodities for which different rates should be charged.

Currently the water quota allocation system is based on a per hectare basis and not on a volumetric basis. This totally distorts incentives for efficiency in irrigation water application and while indirectly stimulating leaching, can contribute to large environmental externalities. The results clearly indicate that improved returns can be generated from effective leaching and optimizing enterprise composition for an expected water quality. As long as the current water-pricing system prevails, greater returns from leaching more than compensate for the pumping costs involved.

The trade-off that still needs to be quantified is between leaching, which is essential to maintain the socio-economic sustainability of irrigation agriculture, and the downstream effects of increased leaching. Without leaching, current irrigated areas will develop into an ecological wasteland, and through leaching the downstream ecological balance can be disturbed and other irrigation areas impacted on through increased irrigation water salinity.

The importance of water as a natural resource that supports the agriculture on which society is dependant for food and fibre is obvious. The extent of the effects that unsustainable irrigation agriculture can have on the degradation of land & water resources and the potential social and environmental impacts that could follow are however less obvious and hopefully recognised as a research priority to better understand irrigation as the blue revolution unfolds.

## REFERENCES

- BACKEBERG, G.R. BEMBRIDGE, T.J., BENNIE, A.T.P., GROENEWALD, J.A., HAMMES, P.S., PULLEN, R.A. & THOMPSON, H. (1996). *Policy proposal for irrigated agriculture in South Africa*. Discussion paper. July 1996. W.R.C. Report No. KV96/96. Beria Printers: Pretoria.
- BASSON, M.S. (1997). *Overview of the Water Resources Availability and Utilisation in South Africa*. Department of Water Affairs and Forestry Report P RSA/00/0197. Cape Town: CTP Book Printers.
- DU PLESSIS, (1982). *Die uitwerking van verswakkende water kwaliteit op die opbrengs van gewasse langs die Benede-Vaalrivier*. Departement van Landbou. Navorsingsinstituut vir grond en besproeiing, Verslag 987/174/82.
- DWAF. (1993). *South African Water Quality Guidelines. Volume 4: Agricultural Use*. Department of Water Affairs and Forestry (First Edition 1993).
- GOUWS, J.A., NEL, P. & BROODRYK, S.W. (1998). *Quantifying the impact of salinisation of South Africa's water resources with special reference to economic effects*. Volume 3: Agricultural sector. Draft document for the WRC by Urban Econ.
- KIJNE, J.W., PRATHAPAR, S.A., WOPEREIS, M.C.S & SAHARAWAT, K.L. (1998). *How to manage salinity in irrigated lands: A selective review with particular reference to irrigation in developing countries*. SWIM PAPER 2. Colombo, Sri Lanka: International Irrigation Management Institute.
- MOOLMAN, J. & QUIBELL, G. (1995). *Salinity problems at the Douglas Weir and Lower Riet River*. Institute for Water Quality Studies – DWAF. Report Number N/C900/29/DIQ1495
- NEL, J.P. (1995). *Kriteria vir besproeiingswater van gronde in die Rietrivier en Laer Vaalrivier wat deur die Oranje-Rietkanaal bedien word*. Instituut vir Grond, Klimaat en Water. Verslag Nr. GW/A/95/5
- PARKER & SUAREZ (1990) *Irrigation water quality assessments* In: (Ed. TANJI, K.K) *Agricultural Salinity Assessment and Management*. ASCE Manuals and Reports on Engineering Practice No. 71. American Society of Civil Engineers: NY.
- POSTEL, Sandra. (1999) *Pillar of Sand: Can the Irrigation Miracle Last?* Worldwatch Institute. W.W. Norton & Company: NY.
- SECKLER, D., BARKER, R. & AMARASINGHE, U. (1999) *Water Scarcity in the Twenty-first Century*. International Journal of Water Resources Development Volume: 15 Number: 1 Page: 29 – 42. Carfax publishers.