



**IMPACT OF LAND USE ON RIVER BASIN WATER BALANCE:
A CASE STUDY OF THE MODDER RIVER BASIN, SOUTH AFRICA**

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Briefs for Knowledge Base of the Dialogue on Water, Food, and Environment

In a new paradigm shift related to integrated water resources management in the context of a river basin, attention is being drawn to consider the upstream and downstream impacts on the various water use activities. With the recognition of significant reuse of water, the river basin is increasingly acknowledged as the appropriate unit for analysis and management of water resources, especially as water availability at the basin level becomes the primary constraint to agriculture.

The ultimate goal of water resources policy in a river basin management is to increase the beneficial utilization of the rain water falling in the catchment through reduction of non-beneficial losses and water pollution. Rain water harvesting coupled with appropriate farming practices can contribute towards achieving the goal of increasing the beneficial use of water in a river basin. The In-field Rain Water Harvesting (IRWH) technique introduced to the small scale communal farmers in the Upper and Middle Modder River basin is one such practice designed to increase crop yields under dryland production, compared to conventional tillage, and hence increase the rain water productivity.

The Upper and Middle Modder River Basin (UMMRB) in South Africa is important because of its location near to one of the fairly densely populated areas in the central region of South Africa. About 35% of the basin consists of communal farming area where subsistence farmers have difficulty in growing enough food for themselves because of

marginal conditions for crop production. The limiting factors are low and erratic rainfall and excessive water losses due to runoff and evaporation from the predominantly duplex and clay soils. According the Land Survey Staff¹ (2000) of South Africa this area is considered to have a very low potential for crop production.

In an attempt to improve the crop production potential of this area the Institute for Soil Climate and Water of the Agricultural Research Council has introduced the IRWH technique. This technique has been shown to increase yields of maize and sunflower by around 30 - 50% compared to conventional tillage. Runoff is reduced to zero where this technique is employed. Because of this fact it was realized that widespread application of the IRWH technique in the UMMRB could reduce runoff from the catchment significantly. The main aims of this project were to investigate to what extent this was a possibility, and furthermore to produce information to “improve the management of scarce water supplies available for agriculture” in the UMMRB. The research questions were: what is the potential expansion of the IRWH technique; what will the implications of this practice be downstream of the river basin if used on a wide scale; and what is the water productivity under “on-site” and “off-site” use of rain water?

The first step in the project was to identify the area of land suitable for the IRWH technique in the UMMRB based on soil type and topographical features. It was estimated that 27.2% of the total area was suitable, consisting of approximately 15 000 ha in the communal farming area and 65 667 currently farmed by commercial farmers. A socio-economic survey was conducted in the communal farming area using a participatory approach to assess to what extent the application of the IRWH technique may expand there. Results showed that a fairly rapid expansion within home gardens could be expected, but that expansion to large areas of croplands was expected to be dependant on the solution of socio-economic constraints such as poverty, lack of appropriate tools and implements, and lack of crop farming skills. The total area covered by home gardens is relatively small; therefore the expansion in the application of the IRWH technique on home garden scale is not expected to significantly reduce runoff in the Modder River.

¹ Land Type Survey Staff 2000. Land Type Inventory Report. Institute for Soil, Climate and Water, Agricultural Research Council, Pretoria.

Assessment of the impact of the IRWH technique expansion to all the suitable land (i.e. 80 667 ha) in the UMMRB showed that the estimated mean annual runoff would be reduced by $25.75 \times 10^6 \text{ m}^3$ from a total of $94.42 \times 10^6 \text{ m}^3$. Calculations were then made to compare the use of rainfall on the 80 667 ha of land in the catchment by the two strategies: (a) allowing the 80 667 ha to remain under grassland and using the runoff for irrigating maize downstream; (b) utilizing the rainfall on the 80 667 ha of land for maize production using the IRWH technique.

The comparison of the total maize production under the two production strategies indicates that the use of rain water harvesting presents an ample opportunity for the small-scale farmers in the basin to increase crop yields compared to conventional farming. The expected downstream (off-site) maize production under irrigation using the runoff water from an area of 80 667 ha of land (IRWH suitable area), at an estimated yield of $10 \text{ t}\cdot\text{ha}^{-1}$, is 23 036 tons, whereas the use of the IRWH technique on the same area (on-site), at an estimated yield of $1.7 \text{ t}\cdot\text{ha}^{-1}$ would give 137 134 tons of maize. This result clearly shows the benefit in this case of using the rainfall on-site for crop production.

The economic analysis conducted made it possible to compare the benefits of the grazing plus the irrigation strategy to that of the IRWH technique. The gross margin on irrigation plus grazing strategy amounted to $0.0254 \text{ R}\cdot\text{m}^{-3}$. The comparable figure for the IRWH strategy was $0.0354 \text{ R}\cdot\text{m}^{-3}$. These results provide economic support for the conclusion that it would be a wise catchment management decision to allow the IRWH technique to be developed in the suitable areas of the UMMRB. A socio-economic report by Kundhlande² *et al.* (2004) on the communal farmers in the Modder River basin indicated that a family of five needs about one ton of maize per annum to meet their staple food requirement. According to this estimate, the expected maize production on the approximately 15 000 ha of the IRWH suitable land in the communal farming area within the UMMRB would be sufficient to supply the staple food for 127 000 people.

² Kundhlande, G., Groenewald, D.C., Baiphethi, M.N., Viljoen, M.F., Botha J.J., van Rensburg, L.D. & Anderson, J.J., 2004. Socio-economic study on water conservation techniques in semi-arid areas. Report No. 1267/1/04. Water Research Commission. Pretoria.

This study provided the information needed for the relevant catchment management decision regarding wise use of rain water falling on the 80 667 ha of land in the UMMRB considered being suitable for the IRWH technique. The study clearly showed that from all points of view, i.e. water productivity, social considerations and economics, it would be a wise decision to allow the IRWH technique to be expanded in all the suitable areas of the UMMRB. However, what may become a regulating factor in the future is the growing need for more water for municipal and industrial purposes in the ever growing Bloemfontein, Botshabelo and Thaba Nchu regions. This is an issue that needs to be addressed using very reliable information regarding the relative importance of saving water for future growing urban and industrial demand, versus solving the current dire situation of small scale farmers, who are struggling to meet their household food security in a more sustainable way.

Moreover, issues such as limiting the rural migration to urban areas through rural job creation activities, such as the implementation of the IRWH technique, should be given serious attention. This problem has surfaced recently in South Africa through the high demand in urban areas for housing subsidies from the government. The problem has been exacerbated by increasing rural to urban migration, inflating the number of beneficiaries above what the government was prepared for.

However, it should be emphasized that water loss reduction and control are considered to be parts of basin-wide integrated water resource management, which gives an essential role to institutions and policies in ensuring that upstream interventions are not made at the expense of downstream water users. These principles apply at all scales, from field to basin levels, but the associated options and practices require different approaches at different spatial scales. Therefore, there is a need to identify the types of policies and incentives that will work best in promoting adoption of new production techniques and cultural practices which increases water productivity at all levels.