ASSESSMENT OF THE POTENTIAL ADOPTION OF INFIELD RAINWATER HARVESTING TECHNIQUE IN THE COMMUNAL FARMING AREAS OF THE UPPER AND MIDDLE MODDER RIVER BASIN, SOUTH AFRICA

P.S. van Heerden[1], Y.E. Woyessa[2] & E. Pretorius[2]

Correspondence author: Mr P.S. van Heerden, Consultant: Agricultural Extension and General Irrigation Practice, P.O. Box 11632, Universitas, Bloemfontein 9321, South Africa, Tel.: +27-051-446-1521, Fax.:+27-051-4462213, e-mail: psvh@mweb.co.za.

Keywords: Adoption, infield rainwater, harvesting technique, communal farming.

ABSTRACT

River basin is a geographical unit that defines an area where various users of the basin's water interact. In a river basin there are many water-related human interventions that modify the natural systems and impact on those who live downstream. Researchers from the Agricultural Research Council's Institute for Soil, Climate and Water (ISCW) have developed an infield rainwater harvesting (IRWH) technique for small-scale farmers in the Modder River basin. This technique increased crop yield significantly compared to conventional practices. Since the start of its dissemination by the ISCW programme, adoption at a homestead level grew from six to more than 950 households. The suitable land for the IRWH in the study area is estimated to be 80 667 hectares, of which approximately 14 500 hectares are in the communal farming area. If all the suitable areas were to be put under IRWH practice, a decrease in the runoff could be expected, with consequences on down-stream water users. A field survey conducted using a participatory methodology on a sample of 21 villages selected randomly, revealed that there are strong positive motivators, such as increase in crop yield and more food available for the household which explain the rapid expansion of IRWH in homestead application. However, some very strong demotivators were identified, such as high levels of poverty, limited

[1] *Consultant, Agricultural Extension and General Irrigation Practice, P.O. Box 11632, Universitas, Bloemfontein 9321, South Africa.*

[2] *School of Civil Engineering and Built Environment, Central University of Technology, Free State, Private Bag X20539, Bloemfontein 9300, South Africa.*

family labour for the preparation of the plots, lack of tools, and the lack of fences around community gardens which could lead to theft and damage by animals. It appears that the demotivators identified are strong enough to prevent a significant expansion of the IRWH technique beyond homestead scale. Hence the expected impact on water availability for downstream users is expected to be minimal.

1. INTRODUCTION

The river basin is a geographical unit that defines an area where various users of the basin's water interact. Along the path of water flowing in a river basin are many water-related human interventions, including water storage, diversion, regulation, distribution, application, pollution, purification and other associated acts to modify the natural systems. These activities have a potential impact on those who live downstream (Sunaryo, 2001).

In the past few years the Institute for Soil, Climate and Water of the Agricultural Research Council (ARC-ISCW) of South Africa has been developing an infield rainwater harvesting technique (IRWH) for communal farmers with the objective of harnessing rainwater for crop production (Hensley, Botha, Anderson, Van Staden & Du Toit, 2000). It has been shown that this technique (Figure 1) resulted in a significant increase in crop yield compared to conventional practices (Hensley *et al*., 2000).

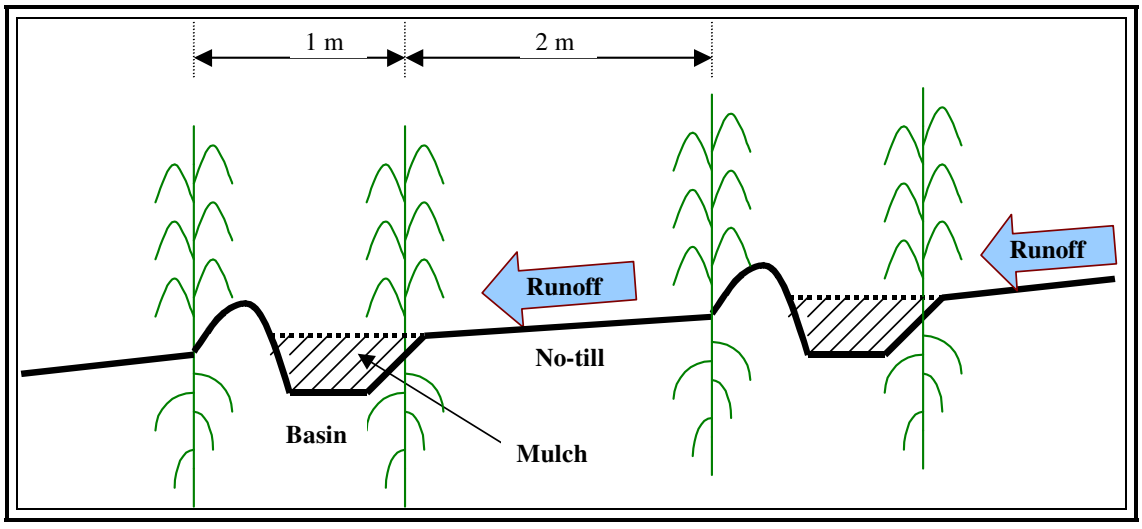

Figure 1: Diagrammatic representation of the Infield Rain Water Harvesting (IRWH) technique (after Hensley, *et al*, 2000)

Moreover, evaporation from the soil surface was reduced considerably, and runoff from the field was reduced to zero.

The development and application of the IRWH technology has followed a phased approach. Primary research on the development of the technique was completed as phase-I at the Glen Agricultural Institute's experimental fields and on farmers' fields by the ARC-ISCW. Dissemination of information about the technology and motivating communities to apply it in backyards in the Upper and the Middle Modder River basin (UMMRB) area has been taking place since the commencement of the project in 1996, with greatly intensified effort since 2000 by local people who were trained for the task. This intensified dissemination phase started with six homesteads from four villages and expanded to 300 homesteads from 16 villages towards the end of the 2003/04 season. A survey by the ARC-ISCW team during October 2004 revealed that more than 950 homesteads from 42 villages have prepared the IRWH structures in their backyards for crop production during the 2004/05 season.

The next phase of the project, the application of IRWH beyond backyard garden scale, has started soon after this research was done. Taking into account that the average homestead has access to between 1.5 and 3 ha of cropland in the communal farming areas, the potential current application area is between 1400 and 2900 ha, with the potential of expanding to the 14 500 ha suitable for the application of this technique in the communal farming area, provided that potential constraints to this expansion are addressed pro-actively. Reducing run-off from this area from 6.6% (Midgley, Pitman & Middleton, 1994) to 0% could have an impact on the water supply to the down-stream users.

However, in order to arrive at an estimate of the extent of the potential spread of the application of IRWH techniques, information on the extent of adoption of this practice by the communal farmers as well as the farmers' perceptions, need to be known. Therefore, the research questions were:

- What are the perceptions and attitudes of communities towards the IRWH technique?

- What will be the future possible expansion of this practice in the UMMRB?

The objective of this paper is to present the results of a survey conducted in the communal farming areas of the UMMRB where this technique is practiced. The main aims of the research were to understand the extent of adoption of the IRWH technique and its possible expansion in the UMMRB. It is believed that this will contribute towards assessing possible impact of IRWH technique on the hydrology of the river basin.

2. MATERIAL AND METHODS

2.1 Description of the Modder River basin area

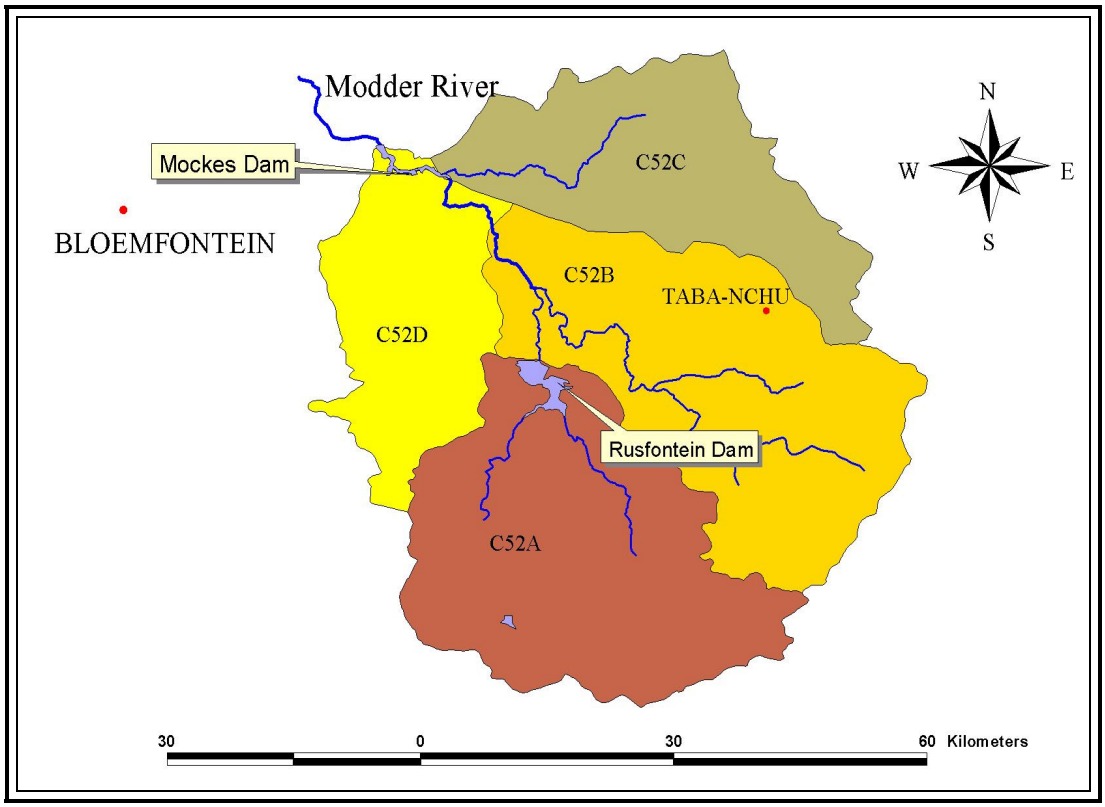

Figure 2: Delineated sub-catchments in the Upper and the Middle Modder River basin

The Modder River basin is a large basin with a total area of 1.73 million hectares. It is divided into three sub-basins, named as the Upper Modder, the Middle Modder and the Lower Modder. It is located within the Upper Orange Water Management Area to the east of the city of Bloemfontein (central South Africa). The irrigated agriculture in the basin draws water mainly by pumping out of river pools and weirs. However, most of the rural developing farmers rely on dryland agriculture for crop production. The water supply to the middle and lower reaches of the Modder River is stabilised by the Rusfontein and Mockes dams in the east and Krugersdrift Dam in the west of the city of Bloemfontein.

The IRWH technique has been introduced in the communal farming areas of the UMMRB. Accordingly four quaternary catchments, hereafter referred to as sub-catchments, were selected for the purpose of this study (Figure 2). These sub-catchments, C52a, C52b, C52c and C52d, are located in the UMMRB.

2.2 Theoretical background to the study approach

The approach to this study is based on the premise that the same factors that enhance the adoption of an applicable innovation will also enhance its expansion to fill a suitable geographic area, provided that no other limitations are experienced. Adoption of innovations by a person or a community is a process, the rate of which is determined by the characteristics of both the innovation and the person. The process that a person goes through is step-wise, consisting of awareness, interest, evaluation or comparison, trial and adoption or rejection (Rogers & Shoemaker, 1971 and Bembridge, 1993).

A further point of interest is that all the members of a community do not adopt innovations at the same speed. An adoption curve has been constructed which classify people in terms of their speed of adoption of innovations (Rogers & Shoemaker, 1971 and Bembridge, 1993). This adoption category curve could be transposed as a cumulative curve that shows the typical sigmoid pattern of growth (Figure 3). This curve is very typical of adoption trends in a community; at first the adoption rate is slow when the innovators test and adopt a practice, then the adoption rate accelerates as first the early adopters and then the early

majority adopts, after which the adoption rate decelerates more and more as the late majority and eventually the laggards adopt a practice.

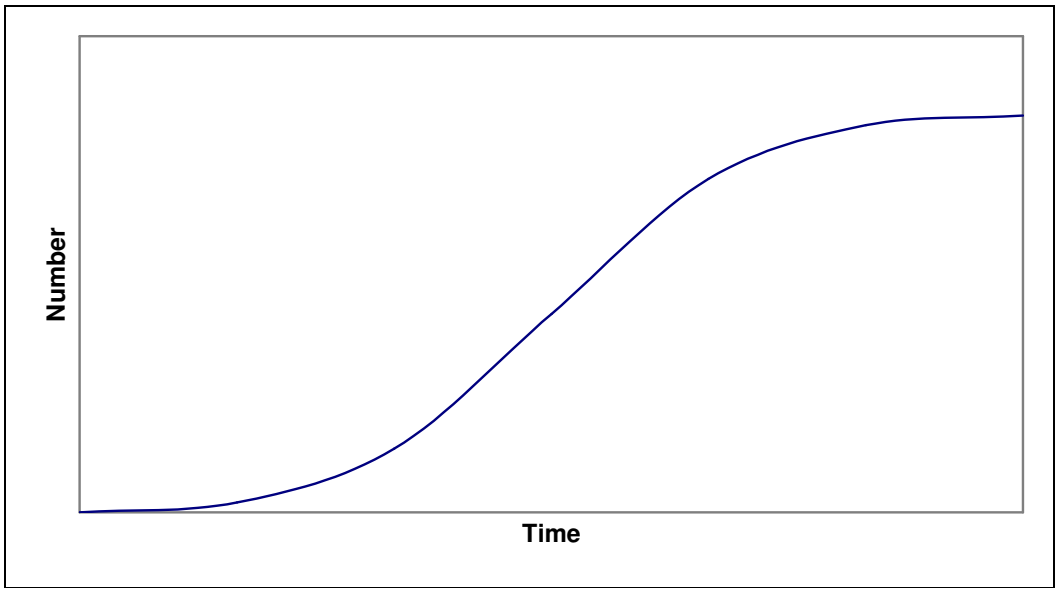

Figure 3: The cumulative adoption curve

The characteristics of an innovation also influence the adoption process as well as the rate of adoption. Rogers & Shoemaker (1971) and Bembridge (1993) described the factors; relative advantage/cost, complexity, visibility, divisibility, compatibility, utility and group action and their influence on the adoption process. Botha, Steyn & Stevens (2000) and Bembridge (2000) indicated the necessity for extension services being in place at the start of a project that has the adoption of an innovation as an objective. Extension workers should use the stages in the adoption process to plan a communication strategy.

2.3 Survey methodology

To predict the possible changes in the application of IRWH and its effects on local runoff, one needs to determine the present situation regarding the application there-of and determine motivators and/or demotivators that could lead to adoption or not in the future. This information could then be used as a predictor of future expansion.

It was expected that the literacy level of the target communities would be low; therefore the survey was based on a participatory approach using semi-structured interviews and small-group discussions as described by Salomon (1998) and Van Zyl (1999). This approach is a cost-effective yet reliable way of getting information regarding target communities (Bembridge, 1993). The questionnaire was constructed in such a way that the presence of a concept and its perception by the community could be tested. A positive response or the mentioning of keywords or key concepts during discussions with the community would imply knowledge of or a positive perception. The absence of a keyword or concept would indicate ignorance or disinterest. A non-leading question regarding the item to be discussed was put to the group and they were prompted to discuss it amongst themselves in the presence of a facilitator. The facilitators then noted or marked keywords and concepts mentioned by the group. There was also space to indicate negative perceptions, especially if these were emphasised.

2.4 Sampling

A sample of 21 villages was selected randomly out of 45 villages. The groups interviewed were not of equal size, therefore a weighting factor, based on group size, was built into the analysis.

3. RESULTS AND DISCUSSION

3.1 The villagers and their economic conditions

The villages are mostly small, with an average of about 160 houses in each, but with a range from about 50 to about 900. The bigger communities (Ratau, Ratlou and Selosesha) form part of the town of Thaba Nchu. Except for these three villages, the population composition found in the villages are not normal, in most cases older women predominate, children are noticed in most of the villages and in some cases elderly men are also noticeable. Bembridge (1987) found similar patterns in rural areas of Transkei, Ciskei and Kwazulu-Natal where men and women of working age were employed elsewhere. Family size ranges from 4 to 12, with an average of about 6.5. In 68% of the cases family labour is available to help with the preparation of the IRWH plots, but this is a qualified help, as it is mostly the children, and they can only help during weekends or holidays when there are no school

activities. In cases where both the father and mother work elsewhere and where grandparents are not available one usually find that the elder children accept the responsibility for the housekeeping, sometimes under supervision of a neighbour. In this area poverty level is very high. Botha *et al*, (2003) describes the living standards in the villages as: "extreme poverty, hardship and suffering, hunger, poor housing". In most cases people survive only on social grants and child support grants. A study by Steyn & Bembridge (1989) found that 94% of the income of rural families came from outside sources and the balance of 6% from farming, which corroborates this finding.

3.2 Sources of information on the IRWH technique

A total of 335 people were involved in this survey. The point of entry was to identify the sources of information on the IWRH technique. These results are depicted in Table 1.

Table 1: Sources of information on the IRWH technique for the first time

Source of information	Percentage of the respondents
Family member	5
Neighbour	37
In a neighbouring village	39
Research or extension workers	42
Field or demonstration day	33
Water harvest festival	0

The percentages in Table 1 add up to more than 100%, because a group could indicate more than one source. The result shows that a relatively high percentage of research and extension workers were identified as a source, an indication that the frequent visits by the ARC-ISCW team has paid off. High ratings are also given to neighbours, neighbouring villages and field or demonstration days as sources.

3.3 Understanding of the IRWH technique

The villages developed an understanding of the IRWH technique through either applying the technique or through observing the

technique applied in their vicinity. Their understanding of the technique is depicted in Table 2. The result shows that the concept of water harvesting and its related water storage in the soil for plant use has been accepted by most of the people that were included in the survey and that they understand it. With the use of IRWH, 86% of respondents indicated that they have more food available to the household.

Table 2: The groups' understanding of the IRWH technique

Groups' understanding of the technique	Percentage of the respondents
Stops running water	91
Water storage in the soil	59
More plant available water	53
More food for the household	86
Surplus produce for sale	43

Ninety percent (90%) of the respondents indicated that they applied the technique in their home garden while eight percent planted in both community garden and home garden and two percent in a community garden only. Reasons given as to why a general expansion from home garden to community garden has not taken place were lack of fencing around community gardens with a resultant animal damage to crops, the non-affordability of cultivating bigger areas and the prevalence of theft where the eye of the owner is not near.

3.3 Experience of the IRWH technique

The respondents' reaction to what they have experienced in the application of the IRWH technique is shown in Table 3. It can been seen from Table 3 that the majority of the respondents have experienced an increase in crop production, more food for the family, perceived the technique as being easy to understand and that they could make money by selling surplus produce, which seems to be strong positive points that could act as motivators for expansion. However, only 25% had their own tools and had to borrow tools for the preparation of the IRWH plots.

Analysing the experience of the respondents against the influence of characteristics on the adoption of an innovation as described by Rogers & Shoemaker (1971) and Bembridge (1993), one finds both expected and some unexpected results as discussed below:

- **Relative advantage**: The technique is expected to give a higher yield for the same effort required when growing a crop. The initial land preparation for IRWH requires more labour than conventional tillage and for some people this might be a demotivator regardless of the higher yields obtained with IRWH. The results in Table 3 shows that 78% of the respondents experienced an increase in crop production, 67% had more food and 50% could sell surplus produce. However, 38% perceived that the IRWH plots were easy to prepare and 22% experienced a feeling of well-being by being able to produce their own food.

Table 3: The respondents' experience in the application of the IRWH technique

Experience in the application of the IRWH	Percentage of the respondents
Easy to understand	67
Have necessary tools to prepare the IRWH plots	25
Testing the idea on a small scale	13
Easy to prepare the IRWH plots	38
Experienced an increase in crop yield	78
Stable crop yield every year	40
More food security	67
Extra income from sale of produce	50
Better feeling of producing own food	22
The results were easy to see	40
Easy integration of the technique with the existing methods of farming	14
Improvement over existing ways of producing crops	16
Group or community pressure for adoption of the technique	14

- **Complexity:** The technique was perceived as, easy to understand, by 67% of the respondents. This confirms the researchers' point of view that IRWH is a simple technique that could be applied by any community (Botha *et al.*, 2003).

- **Visibility:** Forty percent (40%) said that the results were easy to see and interpret. This is a surprisingly low outcome, as demonstrations showed an obvious difference between the results of conventional tillage and application of the IRWH technique.

- **Divisibility:** The IRWH is very easy to test on a small scale. However, only 13% of the respondents indicated that they see the technique as divisible.

- **Compatibility:** Only 25% indicated that they had the necessary tools to prepare the plots. Tools had to be borrowed from neighbours or from the project team of ARC-ISCW.

- **Utility:** Only 16% saw the practice of IRWH as an improvement over the conventional system, in spite of the obvious differences in growth and yield.

- **Group action:** Only 14% indicated that group pressure influenced their thinking about IRWH, which indicates a very low level of peer pressure or peer involvement in the adoption of the IRWH technique.

3.4 Relative cost of IWRH plot preparation

Table 4 shows that 37% of the respondents paid for help in the preparation of the IRWH plots. The cost was as high as R500 although costs of R220 or less were usually indicated. Thirty-two percent (32%) of those who have paid said the cost was expensive, irrespective of what was paid for the preparation of the IRWH plots. In communities where money is rarely available, having to pay any amount, however small it might be, could place a serious constraint on any development.

Some of the respondents indicated other forms of assistance with the preparation of the IRWH plot (Table 5). Table 5 shows that 66% of the

Table 4: Cost of preparation of the IRWH plots

Responses	Percentage of respondents
Did not pay to prepare plots	63%
Paid to prepare the plots	37%
See it as expensive	32%
Money available from sale of chickens and eggs	19%
Borrowed money from friends	15%

Table 5: Preparation of the IRWH plots

Sources of labour for preparation of IRWH plots	Percentage of respondents
Own labour	10
For free; by family members	9
For payment; by family members	7
For free; by members of the same community	13
For payment; by members of the same community	17
As a community project	36
With outside assistance	8

preparation of the IRWH plots was done with help of other villagers, either as a community project (36%) or on a "I help you, then you help me" basis (13%), or for payment in some cases (17%). Eight percent (8%) indicated outside help, which have been specified as help given by ARC-ISCW during the preparation of the original demonstration plots.

Some respondents have indicated that the technique is too labour-intensive.

4. CONCLUSION

Leaders of the communities are positive in most cases about IRWH, although the odd case of disinterest or absolute negativity was found. The people themselves seem to be demotivated by their lack of farming skills, lack of tools and theft that seems to be fairly prevalent in places. A low level of cooperation was mentioned as well as a fair number of

cases where the biggest problem was described as a lack of motivation. On the other hand, the surveying team was struck by the apparent supportive role that participants of the IRWH technique played to each other. The absence of fences around community gardens allowed livestock free access to whatever could be planted, and that seemed to be a big demotivator against the expansion of the IRWH technique to beyond garden size.

Indications are that a fairly rapid spread of the application of IRWH techniques can be expected within the scope of yard size, but no significant spread to community gardens and beyond, is expected in the short term because of socio-economic constraints. Factors that count for rapid expansion are, amongst others, the good understanding of the technique by the communities, the obviously higher production and more food per family, and the possibility of making some money by selling surplus produce. The support services provided by the ARC-ISCW extension group, such as free supply of seed and fertiliser and the intensive servicing of the communities do have a positive influence on future expansion. However, the high levels of poverty and the fact that the communities have to rely on limited family labour for the preparation and cultivation of these plots limit potential development in most of the cases to a level that can be handled within the frameworks of family labour and limited time available. Furthermore, the lack of tools and the perception that preparation of the IRWH plots is difficult, expensive and labour-intensive, as well as the lack of fences around community gardens which could lead to theft and damage by animals, can be seen as demotivators for the significant spread of the IRWH technique to community gardens or beyond.

It therefore appears that application of the IRWH technique may not expand within the foreseeable future to a level where it will have a significant effect on the hydrology of the Modder River. This conclusion could change if the effects of poverty are alleviated by pre-emptive actions.

REFERENCES

BEMBRIDGE, T.J., 1987. *Considerations in agricultural extension for less developed areas in Southern Africa*. Proceedings of the South African Society for Agricultural Extension.

BEMBRIDGE, T.J., 1993. *The practice of agricultural extension*. Development Bank of Southern Africa. Halfway House.

BEMBRIDGE, T.J., 2000. *Guidelines for the rehabilitation of small-scale farmer irrigation schemes in South Africa*. Water Research Commission Report No 891/1/00. Water Research Commission. Pretoria.

BOTHA, C.A.J., STEYN, G.J., & STEVENS, J.B., 2000. *Factors which influence the acceptability of irrigation scheduling with specific reference to scheduling models*. Water Research Commission Report No 893/1/00. Water Research Commission. Pretoria.

BOTHA, J.J., VAN RENSBURG, L.D., ANDERSON, J.J., HENSLEY, M., MACHELLI, M.S., VAN STADEN, P.P., KUNDHLANDE, G., GROENEWALD, D.G., & BAIPHETHI, M.N., 2003. *Water conservation techniques on small plots in semi-arid areas to enhance rainfall use efficiency, food security, and sustainable crop production*. Water Research Commission Report No 1176/1/03. Water Research Commission. Pretoria.

BOTHA, J.J., 2004. *Personal communication*.

HENSLEY, M., BOTHA, J.J., ANDERSON, J.J. VAN STADEN, P.P., DU TOIT, A., 2000. *Optimizing rainfall use efficiency for developing farmers with limited access to irrigation water.* Water Research Commission Report No. 878/1/00. Water Research Commission. Pretoria.

KALANZI, A.S. & DUVEL, G.H., 1999. *Needs assessment in extension: A comparative analysis of structured individual and participative group surveys.* Proceedings of the 33rd conference of the South African Society for Agricultural Extension. Pretoria.

MIDGLEY, DC, PITMAN, WV & MIDDLETON, BJ, 1994. Surface water resources of South Africa. Water Research Commission Report No 298/2.1/94. Vol II Appendices. Water Research Commission. Pretoria.

ROGERS, E.M., 1962. *Diffusion of innovations*. The Free Press of Glencoe. New York.

SALOMON, M.L., 1998. *RAAKS: A participatory approach to monitor and evaluate research and extension*. Proceedings of the 32nd conference of the South African Society for Agricultural Extension. Pretoria.

STEYN, G.J., & BEMBRIDGE, T.J., 1989. *Farming systems as a tool for research and extension in developing areas*. Proceedings of the South African Society for Agricultural Extension.

SUNARYO TM, 2001. Integrated Water Resources Management in a River-Basin Context: The Brantas River Basin, Indonesia. *In* D.J. BryanBruns, and M.S. Bandaragoda (eds.), *Proceedings of the Regional Workshop*, Malang, Indonesia, January 15-19, 2001.

VAN ZYL, C., 1999. *Participatory programme management as a multi-sectoral approach to agricultural programmes*. Proceedings of the 32nd conference of the South African Society for Agricultural Extension. Pretoria.