Enhancing food and livelihood security in the context of the food and financial crisis: challenges and opportunities for small scale rainwater harvesting and conservation

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Abstract

The world recently experienced the food and financial crisis. The food crisis was an indicator of the challenges towards sufficiently feeding an increasing world population. Food production through rainfed and irrigated agriculture account for the bulk of the freshwater used globally but the water is still sufficient to meet the MDG goal on hunger reduction. Agricultural water management is thus an important challenge for feeding humanity; creates the need to find sustainable methods of managing water that will include all water users. Some of these methods include rainwater harvesting which has great potential in increasing food production as compared to irrigation.

This paper aims to identify challenges and opportunities for small scale rainwater harvesting in enhancing food and livelihoods security. Given the large array of practices that are classified as rainwater harvesting, infield rainwater harvesting (IRWH) developed and mainly practised in the Free State Province, South Africa is used. The technique has been in use in villages around Thaba Nchu for a couple of years. Previous studies have shown that the technique increased yield significantly, reduced risk and thus improved household food security. The paper traces the evolution of the technique based of previous studies and recent data, to identify the potential and challenges faced by adopting households. It is concluded that IRWH has great potential to improve household food security as well as contribute to sustainable rural livelihoods mainly as it can reduce dependence on market sourced food supplies.

Keywords: *food security, livelihoods, rainwater harvesting, household, yield*

1. Introduction

Several reasons were given for the recent food crisis, which was characterised by a "surge in international cereal prices over 2007 and 2008" (Headey, 2010:1). Among these explanations are rising oil prices, growing biofuels demand, evolving Asian diets, declining research and development in agriculture, slowing yield growth, low stocks, macroeconomic imbalances, droughts, and export restrictions (Headey, 2010 & USAID, 2009). There is still debate on the validity of some of these reasons in explaining the recent food crisis since a lot of the early analyses to explain the food crisis were done hastily. Nonetheless subsequent studies have confirmed some of the earlier explanations and also identified and/or emphasized new ones. While there are raging debates on the causes of the food crisis, the impact of the crisis was felt in many parts of the world and in some cases leading to unrest (USAID, 2009; Barron, 2009).

The rise in food prices led to a significant increase in food insecurity among poor households (Baiphethi & Jacobs, 2009 and USAID, 2009). This is partly due to the increased dependence on food purchases as opposed to own food production (Maxwell *et al.* 1998; Ruel *et al.* 1998). As a result food expenditures can be as much as 60–80% of the total income of low-income households (Baiphethi & Jacobs, 2009 and Ruel *et al.* 1998). Therefore, food price inflation leads to poor households having to spend a larger proportion of their incomes on basic food commodities or resorting to poor quality diets (Jacobs, 2009, Aliber, 2009, and Frayne and Pendleton, 2009). Some of the responses by poor households, especially in rural areas, to food price increases include resorting to subsistence production (Bryceson, 2002). In South Africa, the number of households engaging in subsistence agriculture as a main source of food and income is declining, but there is a rise in the number of households engaging in subsistence production as an extra source of food (Aliber 2005; 2009). In most parts of SSA, agriculture is important as a source of food and income, thus livelihoods, for the majority of the rural households (World Bank, 2007). Subsistence and/or smallholder production increases household food security and reduces reliance on cash to feed the household (Baiphethi & Jacobs, 2009) thus releasing cash for other household uses.

While small scale production is important for food security, the productivity of the sector is very low. Therefore increasing productivity of the sector has been central to small holder development and some of the proposed interventions include the use of improved inputs and technologies, especially those requiring low external inputs (Baiphethi *et al*., 2009, Baiphethi & Jacobs, 2009, Smale, 2009). In general, long-term food security for smallholder farmers can be improved by encouraging farmers to pursue sustainable intensification of production through the use of improved inputs (Gill 2002; Reardon *et al.*, 1996; Rockefeller Foundation 2006; Smale *et al,*. 2009; Southgate & Graham 2006) as well as increase in the use of fertiliser, organic inputs and conservation investments.

Among the most common and accessible low external input technologies used in most parts of SSA is rainwater harvesting and conservation which improves water access for domestic and agricultural production under rainfed systems. Rainwater harvesting is based on the collection and storage of rainfall water for use in meeting demands of human consumption or human activities (Barron, 2009). There are several technologies that may be classified as rainwater harvesting practices and techniques. The paper concentrates on one specific such practice called infield rainwater harvesting (IRWH) as practised in the Free State province, South Africa. The paper primarily traces the evolution and development of the IRWH technique in Thaba Nchu as well as the possible contribution or impact of using the technique on household food and livelihood security. From these the paper further identifies the challenges and opportunities facing households that have adopted and adapted the IRWH technique. It is expected that these will inform potential expansion of the technology within and outside the community and thus help in ensuring sustained adoption of the technology and others like it.

The rest of the paper is arranged as follows, section 2 gives an overview of the study area and the IRWH technique, section 3 gives the methodology followed by section 4 which presents the results and discussion. Finally the paper concludes and presents some recommendations.

2. Materials and Methods

2.1 Study Area

Thaba Nchu is located 58km east of Bloemfontein and was formerly part of the Bophuthatswana homeland. The area consists of the urban town of Thaba Nchu surrounded by forty-two (42) rural villages (Figure 1). The rural villages can broadly be categorized into peri-urban and deep rural villages.

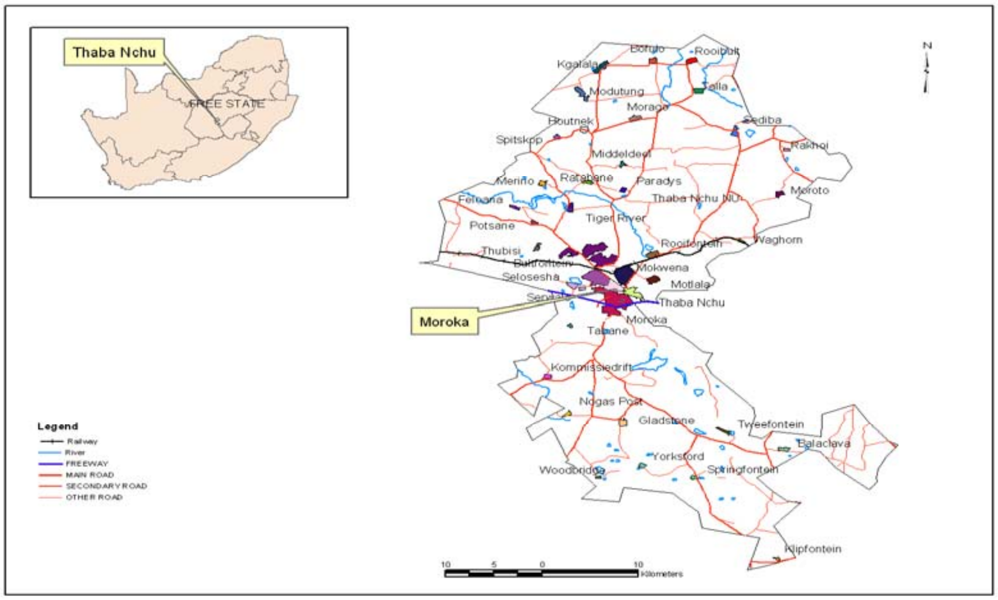

Figure 1: Map of Thaba Nchu and the surrounding villages

The villages make up a total area of 70 364 hectares. Land is divided into three niches; residential, arable and grazing. Residential land accounts for 2.1%, arable land for 12.7% and grazing land for 85.2% of the total land area. Rural Thaba Nchu faces the problems of poverty and food insecurity. The area has very limited employment opportunities outside agriculture, as a result a considerable proportion of the households have taken up the IRWH technique in order to improve their crop production to meet household needs. However, the households and communities face a number of constraints that impede the expansion of the IRWH technique. Addressing some of the constraints and challenges may unlock the potential for households and thus communities to be self reliant in food production and improved rural livelihoods.

2.2 *In-field rainwater harvesting*

As pointed out earlier, the IRWH technique is but one specific form of rainwater harvesting developed and practised mainly in the Free State province. In essence the technique was specifically designed for this area (Hensley *et al*., 2000). The technique comprises a 2-metre runoff strip along the slope of the field and 1-metre basin area across the slope of field and at the end of the runoff strip. In this way, runoff is directed and stored into the basin area (Figure 2).

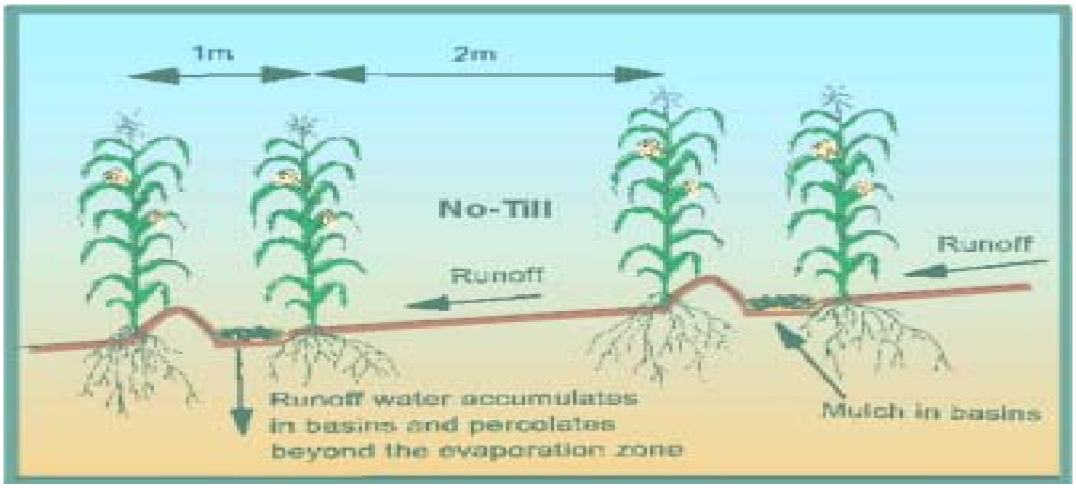

Figure 2: A diagrammatic representation of the IRWH technique

The two metre runoff strip serves as a catchment area, where runoff is concentrated and directed into the storage area, the basins. The vernacular interpretation of this process has resulted in the technique being called *matagwana*, literally meaning small dams. This seems to be an appreciation and understanding or likening this micro-system as following the same principles that underpin the construction and sites of dams

2.3 Data and the analysis

The "data analysis" takes a two pronged approach, firstly tracking or tracing the 'evolution' and research on IRWH in order to determine the challenges and opportunities identified over time. The second part uses data from recent surveys to quantify the costs and returns from the use of the IRWH on farmers' backyard gardens and these are compared with those from the demonstration plots. This is done so as to quantify any changes that may have occurred as well the possible implications of those changes.

2.3.1 Tracking IRWH research and adoption in Thaba Nchu

The work of this part is mainly based on a study by Blignaut and Sibande (2008) with the title *In-field rainwater harvesting and water conservation: assessing the impact of fifteen years of WRC-funded research in Thaba Nchu*. By and large the exercise is an exploratory one based on the above and other sources of information like published papers, conference papers, etc that may assist in tracking the evolution of IRWH as well as the challenges and opportunities raised, whether they have been addressed or not and their implications of the continued use of the technique.

2.3.2 Household survey data

The survey data were collected during 2007 and 2009, these two sets of data holds important demographic information about the users and non-users of the IRWH technique. While the 2007 data may be more generally looked as baseline data, the 2009 survey was performed on selected households and thus will shed more light on the status of IRWH, the challenges and opportunities as well implications on household food and livelihood security.

3. Results and discussion

3.1 Tracking the development and/or evolution of IRWH in Thaba Nchu

In order to track the development of IRWH in Thaba Nchu, several scientific reports, published papers, conference papers and other written relevant materials were used. Specifically, the exercise looks at different studies or papers, what their main aims were, the main findings, conclusions and recommendations. Of primary concern is determining the challenges and opportunities that these papers or reports identified. The findings from the exploration are presented in Table 1.

Table 1: Summary of some selected scientific reports, papers and other relevant written material on the development of IRWH technique in Thaba Nchu[1]

Title **Authors** **Year**	**Material type**	**Relevant issues addressed**	**Main findings and/or conclusions**	**Opportunities**	**Challenges**
Optimising rainfall use efficiency for developing farmers with limited irrigation water ARC-ISCW[2] 2000	WRC Report	1. Technical-low crop production due low and erratic rainfall and marginal soils 2. Transfer of the technology developed (IRWH)	1. IRWH increases yield significantly (~50%) 2. Established demonstration plots to be used on information days for extension officers and potential users of the technology	1. Increased used from the suppression of water loss (runoff) and reduction of evaporation 2. Demonstration plots served to show the crop development at different stages of growth, encourage farmers to take up the technology	1. Ensuring that as many farmers and extension officers access the demonstration plots 2. Extension strategy should the farmers be interested in the IRWH 3. Only the technical aspect of the IRWH but social and economic feasibility (sustainability) not done addressed

[1] A more extended summation of some these studies are in Blignaut, J and Sibande, X. 2008. *In-field rainwater harvesting and water conservation: assessing the impact of fifteen years of WRC-funded research in Thaba Nchu*. WRC Report TT444/08

[2] Agricultural Research Council- Institute for Soil Climate and Water

Estimation of rainfall intensity for potential crop production on clay soil with IRWH practices in a semi-arid area UFS-DSCCS[3] 2003	WRC Report	Quantify production risk (yield variations) of the different production techniques (variants of IRWH and conventional (total soil tillage)) under different moisture (rainfall) levels	IRWH yielded 50% more than conventional under a low soil moisture content	Ability to simulate yields under IRWH with high degree of reliability	
Water conservation techniques on small plots in semi-arid areas to enhance rainfall use efficiency, food security and sustainable crop production ARC-ISCW, UFS-DCS[4], DAE[5] and DS[6] 2003	WRC Report	1. Assess performance and sustainability of IRWH on the field (farms and home gardens) 2. Transfer the technology to interested farmers and the Provincial Department of Agriculture	1. Data from experimental and farm trials used to develop a long-term yield, confirmed supremacy of IRWH over conventional tillage in terms of reducing risk of crop failure thus ensuring yields 2. Technology was also transferred effectively with the help of "on-farm" demonstrations 3. Enterprise budgets developed for maize,	1. IRWH more productive and sustainable than conventional tillage 2. Provides opportunity for households to produce more crop , thus more food and/or income to purchase food 3. Potential for widespread adoption and revitalisation of arable production in the selected area	1. Support for farmers adopting the technique 2. More detailed socio-economic analysis to determine the social acceptability and economic viability of IRWH

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[4] Department of Crop Sciences
[5] Department of Agricultural Economics
[6] Department of Sociology

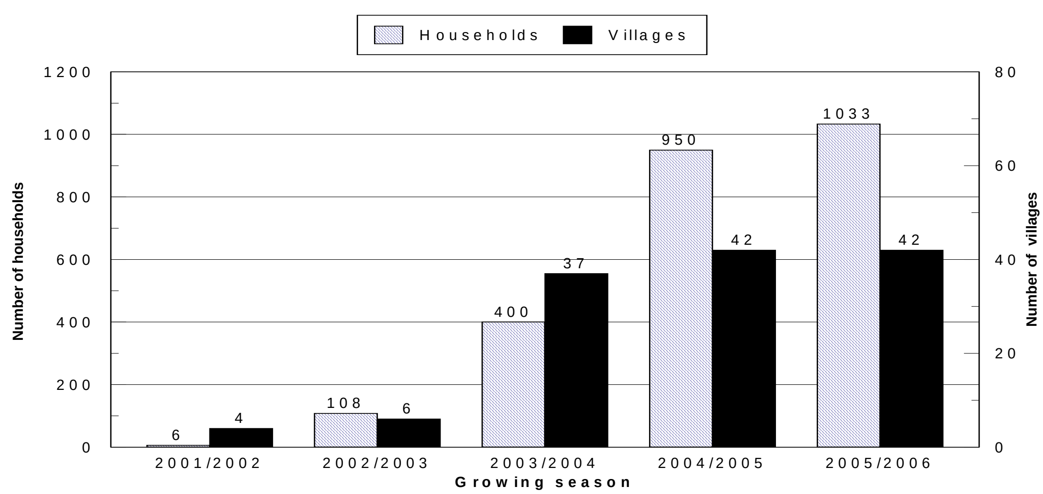
			sunflower and dry beans		
Socio-economic study on water conservation techniques in semi-arid areas UFS-DAE and DS 2004 Study complemented by another 4 Masters theses on different aspects: 3 on economic dimensions and one on the social dimensions of IRWH adoption	WRC Report	1. Assess social acceptability to guide transfer of technology 2. Assess the economic viability of IRWH 3. Assess the sustainability of IRWH 4. Develop a simulation model to determine risk, profitability, resource use- an extension tool	Analysis found that the technique was socially acceptable, economically viable and "environmentally sustainable"	Widespread adoption of the technology as it had benefits to the adopters	Ensuring the continued and sustained use of the IRWH technique Up scaling to larger areas, since currently only employed on backyard gardens
Baiphethi et al, 2006	Agrekon	Assess the impact of employing in-field rainwater harvesting (IRWH) production techniques on household food security for communal farmers in Thaba Nchu, estimate the minimum area of land that a	1. community participation in technology development, dissemination and evaluation is important. 2. For meaningful agricultural research and extension efforts, the farming systems of the envisaged benefactors need to be understood by interacting with the communities in	Estimated land areas were equivalent to what farmers/households already own, at least in the backyard gardens	How do those who do not have access or need to expand their land access and acquire that land Land markets and the possible land transactions?

		representative household needs to cultivate in order to meet its requirements	order to identify and possibly solve the problems. 3. IRWH will contribute to increased agricultural productivity and hence help in the alleviation of poverty and food insecurity		
Baiphethi et al, 2008	Journal paper (Agenga 78)	Exploring the role of women in the adoption and use of rainwater harvesting and conservation (RWH&C)	The majority of the users (70%) are women, heading households, unemployed and dependent mostly on state grants	Women play an important role in the adoption of the RWH&C	Accounting clearly for the gender roles in development, adoption and adaptation of RWH&C
Baiphethi et al, 2009	Journal paper (AJAR)	Explore the role of rural institutions in the adoption and sustainability of IRWH in Thaba Nchu	Minimum farm size is influenced by output levels and by profitability of crop production under IRWH techniques	Develop and/or strengthen institutions that will facilitate the sustained use of IRWH	What are the determinants for successful develoment/enhancement of collective action institutions in Thaba Nchu
Backeberg, 2009	Conference paper (Gernmany)	Explaining the challenging realities of land use in SA and existing opportunities, obstacles for food production and implications for development	The IRWH technique has been developed and has potential for application on communal croplands, which have largely been left fallow Exploitation of the land	Low levels of education in the midst of poverty Reinventing/adjusting the collapsed land tenure system	Demonstration of the technique of larger areas (communal croplands)

			provides opportunity for households to produce surplus above own consumption		

From Table 1, a number of challenges and opportunities were identified from the various studies. While some of the opportunities and challenges were addressed in subsequent studies, the impact of some these are not yet known. There is however consensus in all the studies that the greatest opportunity availed by the IRWH technique is increased yield, therefore increased food and/or income for the household. The practice is currently used only in homestead gardens while communal croplands are not currently used. With expansion to the croplands, households will be able to produce large enough surpluses but there are a number of challenges that still need to be overcome to achieve that[7]. Some of the challenges were seen to be persistent in recent and current studies, which form part of the sections that follow on the current status and impact of IRWH in Thaba Nchu.

Apart from being increased, the technique was found to be socially acceptable and economically viable. This presented an opportunity, as well as the participatory extension adopted by the ARC, for home garden producers to produce enough for their households (food or income from the surplus). Consequently the technology was well accepted by the communities around Thaba Nchu as figure 2 below shows



Source: Botha et al. (2006)

Figure 2: Expansion of the IRWH technique in the study area from 2001 to 2006

[7] See Backeberg 2009 "*Improving rural livelihoods with rainwater harvesting and conservation on communal croplands in South Africa: opportunities and obstacles*" for a more detailed discussion of some of the issues at hand

However, the vigorous increase in the take up of the technology during the period under review in Figure 2 was also coupled with regular support from the ARC as well as functioning IRWH village producer groups. As from about 2007, while there are still a considerable number of households (~500) using the technique and some new entrants, there has been a noticeable drop in the users owing to a number of reasons. Among these reasons were conflicts in the producer group, reduction and finally withdrawal of ARC support. In addition, a commonly cited challenge for the IRWH home gardeners is the availability of markets to dispose of their surplus produce (Mabannda, 2006, Viljoen et al, 2009).

3.2 Current state and impact of IRWH use in Thaba Nchu

This section of the results is based on data from two selected villages which were surveyed 2009 as part of a current study funded by the WRC: *Assessment of the social and economic acceptability of rainwater harvesting and conservation practices in selected peri-urban and rural communities*. It should be noted that in the study, IRWH is but just one of the rainwater harvesting and conservation practices that are found in parts of South Africa. A common aspect around IRWH is the drop in the number of households currently using IRWH, but its importance in improving the lives of the adopters (improved food and income) is well accepted according to respondents in a study by Blignaut and Sibande (2008). This large opportunity is however hampered by among others an inability to expand production to the communal fields due to (ibid: 84):

- Lack of farming implements and machinery (e.g. tractors to cultivate soil as it has been fallow for a long time)
- Crop theft (or threat of) as result of lack of fencing
- Conflicts among community members
- Inadequate water (for supplemental irrigation)

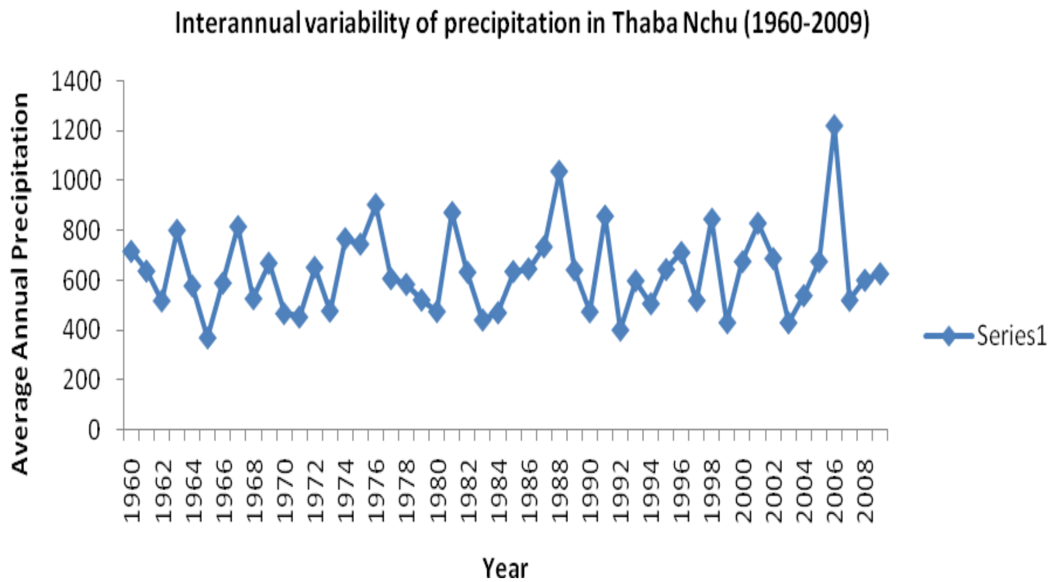
The section that follows presents a comparison of the inputs and outputs from the IRWH between the demonstration plots and the backyard gardens, based on data collected from two villages; Potsane and Rietfontein. As indicated the data was collected in 2001 and 2009. These two periods represent different stages of the adoption of the IRWH technique. In 2001, the production data was from demonstration plots on farmers' backyards whereas the 2009 data from the farmers' backyard garden after substantial support was withdrawn by ARC. Based on the above, the two periods are respectively referred to, in the rest of the paper, as demonstration plots and backyard gardens. It should also be noted that the figures are based on enterprise budgets which are commonly expressed on a per hectare basis for crops. This however, does not discount the fact that households primarily produce on areas far less than a hectare. Table 2, presents the comparison in inputs used and returns for maize and dry beans production in demonstration plots and backyard gardens.

Table 2: Comparison of per hectare (ha) returns and costs for maize and dry beans production in demonstration plots and backyard gardens

	Maize			**Dry beans**		
Enterprise budget Variable	**Demonstration plots**	**Backyard gardens**	**% Change**	**Demonstration plots**	**Backyard gardens**	**% Change**
Yield (ton)	2.81	2.65	***-5.69***	0.69	0.57	***-17.39***
Gross Income (R)	1599.42	1510.50	***-5.56***	2001.00	1650.19	***-17.53***
Purchased inputs (R)	659.30	173.87	***-73.63***	1099.70	739.01	***-32.80***
Labour (days)	29.84	34.26	***14.83***	20.50	29.39	***43.35***
Cost of labour[8] (R)	447.57	513.96	***14.83***	307.52	440.83	***43.35***
Gross margin above purchased inputs (R)	940.12	1336.63	***42.18***	901.30	911.18	***1.10***
Gross margin per labour-day (R/day)	31.51	39.01	***23.81***	43.96	31.00	***-29.48***

From Table 2, there was a drop in yield for maize (6%) and dry beans (17%) with a resultant drop in gross income. However, this could perhaps be attributed to the difference in average annual rainfall as shown by Figure 3, wherein there was higher rainfall during demonstration plots (2001) than for backyard gardens (2008).

[8] Most of the labour used is from the household and the cost relates to if that labour was to be hired.



Source: Gandure, Walker and Botha, 2010

Figure 3: Inter-annual variability of precipitation in Thaba Nchu (1960-2009).

Apart from the drop in yield, there was a significant drop in the use of purchased inputs. These include fertilisers, pesticides, seeds and herbicides. In the case of maize the drop is quite high (74%) as opposed to 33% in dry beans production. The observation is in direct contrast of the movements in yields and gross incomes. While maize had a sharp decrease in the use of purchased inputs, it had a relatively smaller drop in yield, the reverse is observed in dry beans. This may imply that maize production can, under IRWH, strive with minimal use of chemical inputs whereas dry beans require the investment in chemical inputs.

The drop in the use of purchased inputs is coupled with an increase in the use of labour, for maize labour use increased by 15% and dry beans 43%. The increased labour use might be due to increased manual weeding and pest control as well as the sourcing and application of kraal manure on the backyard, which seems to have replaced inorganic fertilisers that were used in the demonstration plots. The above should also be understood in the context that, the backyard gardners are not as fully supported as was the case during demonstration plots. In the demonstration plots, households were provided with all the chemical inputs in the exact amounts that were required. Therefore, the reduced use of the purchased inputs seems to be the direct response to this but also a recognition of alternative means of performing some of the cultural practices.

The reduced use of purchased inputs resulted in higher gross margins (GM), but more significantly for maize (42%) than dry beans (1%). Consequently the returns to labour (GM per labour day) were also positive for maize (24%) as opposed to a loss of almost 30% for dry beans production.

Based on the above observations, it is important to note that backyard gardeners have adopted the IRWH technique but altered some of the "optimal" cultural practices to operate within their means. A case in point might be the reduced use of inorganic inputs, these are normally packaged for the requirements of larger farmers, hence not available in the quantities required by backyard farmers. This might be discouraging use or totally blocking access to such, even when one can afford those quantities, which is quite unlikely. This calls for a consideration and testing of alternative inputs, especially for dry beans, which need to be cheaper and in appropriate quantities for smaller producers.

4. Summary, conclusions and recommendations

The ability for rural and urban households to provide for their sustenance of its constituent members is at the core sustainable livelihoods, and secure and adequate food seems to be a primary focus for most households, thus making food security a primary responsibility of the household. However, due to the low levels of own production and thus dependence on market provision of food, a majority of poor households spend a large proportion of household income on food purchases. The low own food production exists even though most rural households have access to homestead gardens and communal cropping areas. The land is commonly not used due mainly to a lack of appropriate technology, knowledge, inputs and the required access to natural resources since much of the land on which the rural poor are marginal for gricultural production. Therefore this requires that the mix of technology, knowledge, inputs and natural resources has to be right for sustainable production to take effect and thus impact positively on lives of the rural poor.

The IRWH technique in Thaba Nchu was demonstrated as technology that can enhance food security; it increases yields, reduces the risk, thus enhances the ability of the household to produce its own food on backyard gardens. Increased production under IRWH is expected to reduce households' dependence on market sourced food items and therefore the impact of the food price spikes that may result in a household food crisis. However, for the technique to work have the long-term desired livelihood outcomes, it needs to be complemented by a combination of extension support, inputs, collective action, skills development and secure or "assured" natural resource use rights. This mix was shown to be pivotal in expansion of the IRWH technique, since the withdrawal of inputs and extension support led tosome households stopping the use of the technique and those who continued made some adaptations to the technology (specifically in relation to cultural practices (especially use of purchased inputs)).

Therefore, access to affordable purchased inputs seems to be a challenge for a majority of the backyard farmers which has implications on potential yields and thus threatening the sustainable adoption of the IRWH in the communities and the expansion to larger areas. It is therefore recommended that alternative inputs be tested and provided in quantities that backyard farmers can afford. As with any new innovation, there is a need for targetted support for these farmers as they have the potential to be able to constantly supply their communities with food and lower prices and thus assist rural communities in access food.

5. Acknowledgements

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