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Dealing with messy problems: lessons from water harvesting systems for crop production in Burkina Faso

L. Bunclark, J. Gowing & E. Oughton (UK)

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Despite the identification of areas exhibiting successful adoption and use of water harvesting technologies (WHTs) by small-scale farmers in SSA, on the whole WHT use remains low and hence impacts on crop production and livelihoods marginal. Past research has determined the importance of social factors in the adoption and use of WHTs, but little attempt has been made to fully understand their role. This paper presents qualitative, micro level research conducted in Botswana and Burkina Faso that has increased understanding of the effect of social factors. The main lesson learnt is that WHTs sit within a highly complex and dynamic system and the problem of low adoption and use cannot be solved using approaches that attempt to over-simplify it. Ensuring the sustainability of WHTs into the future requires that the complexity and messiness of the system is fully embraced by researchers and practitioners seeking solutions.

Introduction

Rainfed agriculture in sub-Saharan Africa (SSA) holds great promise for improving livelihoods, but the key challenge is to reduce the risk of crop loss that highly variable rainfall, particularly intra-seasonal dry spells, pose to production (Faurès and Santini, 2008). Improvement in the management of ‘green water’ (water that is potentially plant-available and stored as soil moisture)[1] is widely considered to hold the key to increasing rainfed crop production (Rockström et al, 2007). One way in which this can be achieved is through the process of micro-catchment (or in situ) water harvesting, which reduces runoff, encourages infiltration and soil water storage, and reduces levels of soil water evaporation. Micro-catchment water harvesting technologies (WHTs), are commonly used across SSA as they are generally ‘low-tech’ and can be constructed by individual farmers in their own fields with minimal external inputs (Gowing and Bunclark, 2013).

The problem is that despite the identification of numerous ‘Bright Spots’ of successful WHT adoption and use across SSA, on the whole WHT use by small-scale farmers remains low and hence impacts on crop production and rural livelihoods marginal (Biazin et al., 2012). It is generally agreed that the over-arching cause for this is the failure to adapt WHTs to the contexts within which they are placed (Rockström et al, 2007). Past research has determined the importance of ‘software’ (socio-economic factors), along with ‘hardware’ (technical factors) (Critchley et al., 1992), yet little progress has been made on increasing the understanding of the role of social factors (Critchley and Gowing, 2013). There is therefore an urgent need for deeper investigation of the social factors that influence WHT adoption and use, as well as the interaction between factors.

Preliminary research: Botswana

Initial steps to fill the research gap were made by the lead author through an investigation of WHT adoption and use by small-scale farmers in Botswana, southern Africa as part of her studies at the University of East Anglia in 2010 (see Bunclark and Lankford, 2011). Domestic WHTs have been traditionally used in Botswana for many years for homestead supply, but views regarding the suitability of the technology for agricultural production varied. Despite the implementation of several government-led schemes involving

WHTs and attempts to assist small-scale farmers through extension services, WHT performance on traditional farms had been poor, with only 30 per cent of potential yields achieved (Rockström et al., 2010).

Table 1. Decision-making matrix for the suitability of WHTs in agriculture

Factor	Initial adoption	Longer-term sustainability
Climate, land and ecology	• Adequate data on rainfall, evaporation and soil properties to allow for effective design of systems • Potential rainfall and runoff volume and distribution compatible with crop water demand • Soil with good water holding capacity (and sufficient structure if required for any construction in association with WHT system) • Soil nutrient level capable of sustaining crop growth in at least the short-term	• Sufficient availability of water to maintain wider ecosystems in region despite presence of WHT systems • Minimal effects of long-term climate variability on ability of WHT to provide adequate water • Rainfall patterns offer opportunity for enhancement via WHT with little excessive drought or floods (see next point) • Increasingly high unpredictability of rainfall, or failure to provide weather forecasts, to allow for timely farming practice and efficient use of water harvested may impact on use
Farming and livestock practice	• Traditional use of WHT in crop production • Labour and equipment investment acceptable • Costs and benefits compare favourably with livestock keeping	• Combined use of WHT with soil conservation methods and application of fertiliser • Optimisation of farm management skills to decrease limitations on crop production caused by factors other than water availability (eg. seed sowing) • Fits wider farming systems in location
Availability of assets	• Availability of finances, materials and labour required for adoption through subsidies and assistance from appropriate institutions • Adequate land availability and land tenure • Knowledge and understanding of WHT • Low input demand for adoption	• Adequate availability of land suitable for long-term crop production close to homestead • Low input demand for maintenance • Availability of finances, materials and labour required for maintenance through subsidies and assistance from appropriate institutions • Possession of skills to adapt WHT system to meet specific needs of farm/catchment
Livelihood strategies	• Crop production high priority in livelihood strategy • Significant reduction in risk of crop failure with implementation of scheme • Rapid return on initial investment • Lack of conflict with other current livelihood strategies (e.g. pastoral farming) • Crop prices attractive to draw farmers towards production	• No detrimental impact on wider livelihood strategy (eg. diversification) • Provides consistent boost to household income and nutrition • Sustained high priority of agriculture in livelihood strategy • Low competition for resources from other livelihood strategies (eg. formal employment) • Markets for crop produce remain predictable and transparent
Community and catchment institutions	• Government with high capacity to implement relevant policies and schemes • Presence of local level institutions to implement farmer centred research and extension • Assistance of community/village leaders in adoption issues	• Catchment level institutional linkages between upstream and downstream users to monitor and manage water supply and demand within both agriculture and other sectors • Community level institutions to allow for farmer participation in planning, training, cost sharing, continual evaluation and improvement of systems
National support programmes	• Incentivised policies and schemes, including grants and subsidies • Policies encouraging independence of rural population from government	• Complimentary policies encouraging the increased importance and growth of small scale agriculture and crop production. • Provision of infrastructure to increase access to markets • Social protection income for households and drought food aid does not undermine attractiveness of WHT

Source: Bunclark and Lankford, 2011

The aim of the research conducted in Botswana was to determine the range of factors that led to low levels of WHT adoption (in the presence of what appeared to be an enabling environment) and to use this information to propose a decision-making matrix that could be employed by those considering the implementation of WHT systems in similar areas (Bunclark and Lankford, 2011). Drawing on both literature and findings from semi-structured interviews with farmers and key informants in Botswana, the main requirements needed to ensure the suitability of WHTs in any particular small-scale farming context were determined and divided into those affecting initial adoption and those affecting longer-term sustainability of WHTs. The research findings indicated the factors affecting the adoption of WHTs in Botswana in the short and long-term could be categorised as: hydro-ecological factors; availability of assets; rural livelihood and income strategies; local institutional capacity; and national support programmes (Bunclark and Lankford, 2011). The requirements identified to affect the suitability of WHTs in relation to each factor are summarised in the decision-making matrix in Table 1.

In Botswana, the factors identified as affecting the initial adoption and sustainable use of WHTs were shown to occur within the context of a dynamic and interdependent environment where farming systems were variable and the incentives to increase crop production were uncertain (Bunclark and Lankford, 2011). There was therefore a need to test the decision-making matrix in other countries across SSA to allow for further analysis of the factors identified as affecting adoption and use in Botswana and facilitate expansion of the matrix into a more comprehensive implementation framework.

Next steps: Burkina Faso

Further investigation of the factors influencing WHT adoption and use was conducted by the lead author as part of the Water Harvesting Technologies Revisited (WHaTeR) project at Newcastle Universitybetween 2011-2014 (http://whater.eu). The WHaTeR project was a collaborative project between several European and African universities that aimed to contribute to the development of sustainable water harvesting technologies that strengthen rainfed agriculture, rural livelihoods and food security in SSA. Newcastle University researchers collaborated closely with a partner organisation in Burkina Faso, West Africa, the Institut de l'Environnement et Recherches Agricoles (INERA), or National Institute of Environment and Agricultural Research, in the collection of data as part of the project.

As a country within SSA where rainfed farming is conducted in the context of highly variable rainfall and WHTs have been promoted and implemented widely by both governmental and non-governmental organisations over an extended period of time, Burkina Faso provided an excellent place to further analyse and build on the factors identified in the preliminary research conducted in Botswana. Some WHTs are reported to have been used by native Mossi farmers at the turn of the twentieth century, but it was not until the 1960s that several projects led by foreign development, and later national governmental, organisations promoted the improvement of agricultural production via the implementation of WHTs (Kabore-Sawadogo et al., 2013). The technologies gained particular interest after the 1970s as a result of the droughts experienced across the Sahelian region at this time, and by the 1980s and 1990s, there were many projects promoting the implementation of a variety of WHTs across the country (Kabore-Sawadogo et al, 2013). Notwithstanding substantial evidence demonstrating the success of WHTs in the areas that have benefitted from external intervention throughout the past three decades, WHT adoption rates and benefits in other areas of Burkina Faso are much lower (Biazin et al., 2012).

The specific aim addressed by research at Newcastle University was to increase understanding of the adoption and longer-term use of WHTs by male and female small-scale rainfed farmers in SSA and determine more clearly the nature of crop production and livelihood improvements the technologies provide. In order to do so, this research adopted a sustainable rural livelihoods theoretical approach (Scoones, 1998) and multiple case study methodology. Three case study villages (Boukou, Malgretenga and Peni) were selected across central and south-western Burkina Faso for the variation in experiences of WHT adoption and use they provided. Data collection techniques used were qualitative and included focus groups, semi-structured interviews and transect walks, with both key informants and farmers.

What we found

Although the original intention was to test and build on the decision-making matrix previously developed in Botswana, further analysing the factors identified as affecting adoption and sustainable use of WHTs, it quickly became clear that this would not be possible. The data emphasised that WHT adoption and use takes places within a highly complex system, where there is a high level of interaction between the range of factors affecting the success of the technologies. These factors cannot be separated into different categories and timeframes as presumed in the initial research. Furthermore, farmers' decisions on whether or not to adopt WHT were the result of a complex interaction of many different endogenous and exogenous factors, which were highly variable between households and individuals (Bunclark et al, under review).

Research in Burkina Faso reiterated that the adoption and use of WHTs depends not only on the technologies' ability to reduce the level of risk involved in crop production (i.e. their technical ability), but on their synchronisation with farmers' wider livelihood needs, opportunities and constraints, (Bunclark et al, under review), such as livelihood pathway[2], level of asset endowment and land scarcity. Furthermore, many factors related to farming and livelihood systems and hence the adoption of WHTs were heavily influenced by institutions, organisations and norms (structures and processes) that determine what roles it is possible and/or appropriate for different households, and men and women within them, to play. Figure 1 shows the main factors that were found to influence adoption and benefits and the main links between them. Rather than identifying specific individual factors that affect WHT adoption by farmers and the likely benefits they might provide, this research has demonstrated the importance of examining WHTs as part of a complex system, as suggested (Douxchamps et al, 2012).

Besides understanding the factors that affect adoption and use, defining the nature of adoption itself was challenging and complex for WHTs, due to the varied way in which farmers used them. The extent of WHT adoption varied greatly both between and within households. The *nature* of WHT adoption also varied greatly, some farmers had not necessarily adopted WHTs in line with technical specifications or promotion, adopting components or principles of the technologies only. Some farmers were not currently using WHTs but had done so at some point in the past (Bunclark et al, under review).

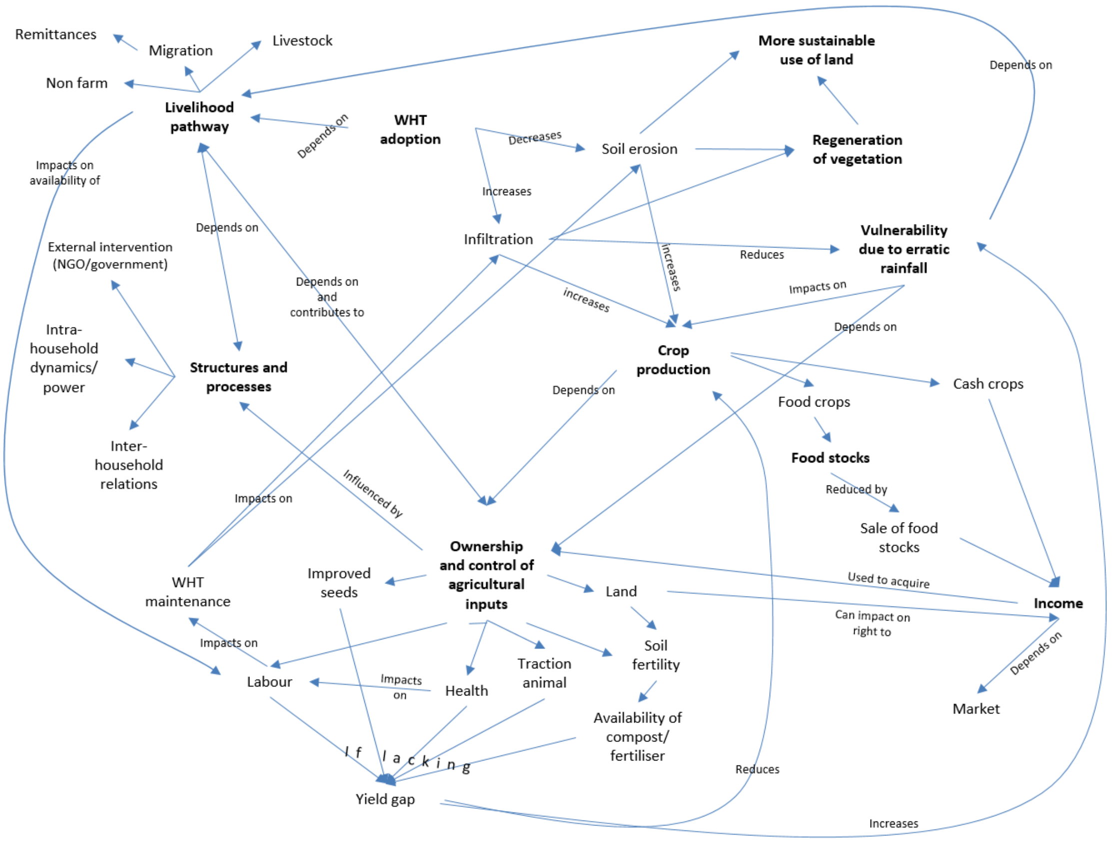

Figure 1. Concept diagram of the main links and interactions between factors that affect the adoption and use of WHTs

Source: Authors

Lessons learnt: embracing messiness and complexity

As an engineer, the lead author initially regarded the low use of WHTs by small-scale farmers and marginal impacts on crop production and rural livelihoods as a problem whose solution could be synthesised using a matrix or implementation framework. However, looking at the problem through a social science lens demonstrated that in reality the solution is too complex and 'messy' and cannot be represented by a series of boxes. Moreover, adoption of technologies designed to reduce water scarcity is not necessarily a linear process that involves a dichotomous choice, but rather it is a product of local innovation: a complex process that involves testing, adaptation, use and dis-adoption to varying degrees and at different stages of the process (Loevinsohn et al., 2013).

Micro level approaches, such as the one used in this research, can give deeper insight into the reasons behind failures and successes of technology use. They can uncover the complexity of underlying institutions and power relations that have a big impact on choices and behaviour of households and individuals over time. They also illustrate that a solution to a problem, whether related to technology adoption, livelihood improvement or another issue, is not necessarily in the form of an answer. Instead, some solutions may focus on identifying different components and relationships that need to be considered and investigated in more detail by those working on the design and implementation of the technologies, projects or programmes concerned. Prioritisation should be given to the examination of the links between institutions (including organisations and social norms) and technology use, as institutional change at a higher level may be required for significant improvements in livelihoods to occur via technological change (Röling, 2009). For example, research in Burkina Faso has highlighted that a better understanding of gender relations at community and household level is needed to ensure that improvements in food security and other livelihood outcomes are maximised.

Problems that limit the potential for sustainability in the water sector are not generally straight forward or simple, neither therefore should the solutions proposed to overcome these problems. Rather than using methods and approaches that attempt to over-simplify and 'box in' complex problems, researchers and practitioners in the water sector seeking to improve sustainability should be using those that embrace and work *with* the complexity and messiness of systems. In the context of WHTs in Burkina Faso, this may involve the encouragement of farmers to innovate and adapt the technologies to their particular set of circumstances, as well as promotion of a range of more flexible WHT options that are better able to meet the various needs and constraints of communities, households and individuals.

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Note/s

1. 'Green water' resources comprise rainfall that has infiltrated and is stored in the soil, accessible to plant roots. This is in contrast to 'Blue water' resources, which comprise water stored in lakes, rivers and aquifers. For more details, see: Falkenmark, M. and Rockström, J. (2004) *Balancing water for humans and nature, the new approach in ecohydrology.* Earthscan: London, UK.
2. 'Livelihood pathway' is defined as "a pattern of livelihood activities which emerges from a co-ordination process among actors, arising from individual strategic behaviour embedded both in a historical repertoire and in social differentiation, including power relations and institutional processes, both of which play a role in subsequent decision making." For more details see: de Haan, L. and Zoomers, A. (2005) 'Exploring the frontier of livelihoods research', *Development and Change*, Vol 36, No 1, pp. 27-47: 45.

Contact details

Lisa Bunclark
Agriculture Building,
School of Agriculture, Food and Rural Development,
Newcastle University,
Newcastle upon Tyne NE1 7RU
lisa.a.bunclark@gmail.com
www.ncl.ac.uk/afrd

John Gowing
Agriculture Building,
School of Agriculture, Food and Rural Development,
Newcastle University,
Newcastle upon Tyne NE1 7RU
john.gowing@ncl.ac.uk
www.ncl.ac.uk/afrd