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Understanding farmers' decisions on adaptation to climate change: Exploring adoption of water harvesting technologies in Burkina Faso

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ABSTRACT

Continued efforts are required to reduce the risk and vulnerability of small-scale farmers in the drylands of sub-Saharan Africa in the face of increasing rainfall variability and long term climate trends. The adoption of water harvesting (WH) is examined as one possible strategy to better conserve agricultural resources and increase production. A case study approach based in Burkina Faso is used to explore farmers' attitudes to innovation via a qualitative methodology. Farmers' experiences of WH adoption and use over time are considered in relation to the 'bright spots' discourse to enable the identification of further lessons about adoption drivers for innovations aimed at reducing risk and vulnerability in small-scale agriculture. By rethinking the conceptualisation and definition of WH adoption, as well as considering use of the techniques over time rather than at the point of initial adoption alone, this research provides evidence of the dynamic nature of WH adoption and use by farmers. It demonstrates that adoption is not a dichotomous decision and that levels of intensification, modification, abandonment and replacement by farmers vary over time. Use of the sustainable rural livelihood framework highlights how this can be linked to the dynamic nature of the systems within which farmers derive their livelihoods and the need to continually adapt to dynamic, irregular and uncertain conditions (vulnerability context). These lessons from WH experience in Burkina Faso have wider implications for the promotion of climate adaptation innovations for small-scale farmers in SSA.

1. Introduction

1.1. Adapting to a changing climate in Sub-Saharan Africa

The IPCC 5th Assessment Report (Niang et al., 2014) points to an increased warming trend across Sub-Saharan Africa (SSA) over the last 50 to 100 years and concludes that it is likely that land temperatures will continue to rise faster than the global land average. African ecosystems are already being affected by climate change, and future impacts are expected to exacerbate vulnerability of agricultural systems, particularly in semi-arid areas. Such macro level changes in-turn influence the complex combination of context-specific environmental and socio-economic factors that have been found to shape risk and vulnerability in farming systems at the local level, including resource availability, resource use intensity, governance, markets and consumption patterns (Sietz et al., 2017). In the recent past, progress has been made in efforts to manage risks to food production from climate variability and the related increase in soil erosion, but continued efforts are required to improve the resilience of agricultural systems. An array of resource-conserving agricultural practices is identified as offering climate adaptation options (Lipper et al., 2014). We focus on one such climate adaptation option − the adoption of water harvesting (WH) by small-scale farmers in order to alleviate drought vulnerability in semi-arid cropping systems.

There are some good news stories; 'bright spots' of successful adoption of 'resource-conserving' techniques by individuals and communities across SSA have been identified (Pretty et al., 2006; Noble et al., 2008; Bossio et al., 2008). These represent cases where land degradation has been reversed or mitigated and household food security and livelihoods have been improved through agricultural innovation. They involve better use of natural resources to increase total farm production, such as through adoption of WH. In the majority of cases, the development of a 'bright spot' has been seen to be contingent on an external priming agent (such as an NGO or government project). Where a 'bright spot' is said to exist, there is evidence that improvements have been sustained beyond the lifetime of this intervention.

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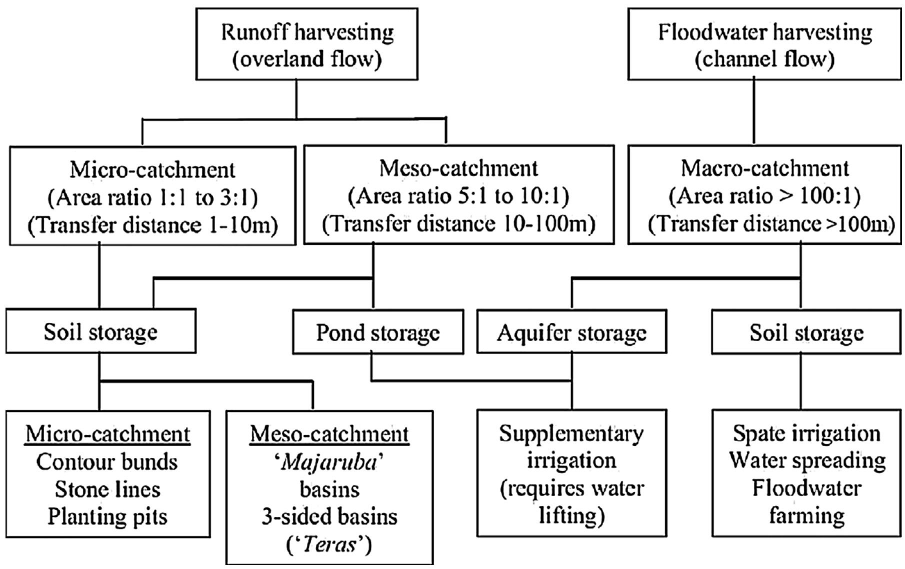

Fig. 1. Classification of water harvesting practices. (Source: Gowing and Bunclark, 2013).

However, evidence for 'spontaneous' adoption outside the project site is generally lacking. We consider how the experience of WH innovation compares to the 'bright spots' discourse and identify some lessons about drivers of adoption of this innovation for reducing vulnerability to both existing climate variability and future climatic changes.

Previous studies have largely viewed WH innovation as a dichotomous decision (adopt Yes/No) as determined by characteristics of adopters and non-adopters at a certain point in time. However, recent research has shown the adoption of WH techniques to be a highly dynamic process, where levels of adoption, modification, abandonment and replacement vary over time (Mazzucato and Niemijer, 2000; Sietz and van Dijk, 2015). Nevertheless, over-simplified conceptualisations of WH adoption still persist. This reflects the '*deeply flawed*' concept of technology adoption that underpins much of the research agenda on agricultural technologies in developing countries (Glover et al., 2016).

This paper focuses on the adoption and use of WH in Burkina Faso, as it represents a good example of small-scale farming and WH use in SSA. Since the 1980s, governmental and non-governmental organisations (NGOs) have continued to actively promote the use of a range of WH across Burkina Faso in a bid to help small-scale farmers, who account for up to 90% of the working population (FAO, 2014). This innovation aims to reduce soil degradation and the risk of crop losses linked to unpredictable and highly variable climate, which were considered the primary constraints to crop production (Sawadogo, 2011; Douxchamps et al., 2012; Critchley and Gowing, 2013). We report an investigation based on extended fieldwork during 2013 and 2014 which attempted to identify drivers of WH adoption while recognising it as a dynamic process. In response to Sietz and van Dijk (2015), we provide insight into the motivation, rate and time of intensification, modification, abandonment and replacement.

1.2. Introduction to water harvesting techniques

In the semi-arid and dry sub-humid zones of SSA, it is not the limited amount of rainfall alone that constrains rainfed crop production. Rather, it is the extreme variability of rainfall, with high rainfall intensities, few rain events, and poor spatial and temporal distribution (Molden et al., 2007). Dry spells occur in almost every rainy season and adapting to these, and future changes to climate, depends on developing appropriate techniques to bridge these dry spells, reduce the risk of crop loss and increase productivity (Lipper et al., 2014). Water harvesting – a broad term often used interchangeably with 'rainwater harvesting' – is an innovation which aims to alleviate this constraint and is widely considered the key to unlocking full potential of rainfed agriculture (Rockström et al., 2007). We adopt the definition proposed by Critchley and Scheierling (2012): "*The collection and concentration of rainfall runoff, or floodwaters, for plant production*". They present a classification of water harvesting systems adapted from that developed by Critchley and Siegert (1991). Other classifications proposed by Fox (in Falkenmark et al., 2001) and Oweis and Hachum (2006) are similar.

In these various classifications a distinction is often made between techniques on the basis of where the runoff is collected and how far it is diverted. Runoff may be collected from fields, hill-slopes, house roofs, roads and tracks, or ephemeral streams and gullies. Rainfall may be captured locally on the farm where it is to be used, or as runoff from rain that falls beyond the farm boundary. The classification adopted here (see Fig. 1) divides water harvesting into floodwater harvesting (channel flow) and rainwater harvesting (overland flow). Water harvesting practices may also be distinguished on the basis of how the captured water is stored. Some rely on storage within the soil reservoir of the cropped field, while others incorporate storage in ponds and cisterns. In the latter case the stored water can then be used for supplemental irrigation on the adjacent cropped field at a time of the farmers' choosing.

Over the last 20 years the literature on water harvesting in SSA has proliferated. Vohland and Barry (2009) limit their discussion to 'in-field water harvesting practices' in African drylands and list 98 references published in the last 20 years. Biazin et al. (2012) deal with 'rainwater harvesting and management' practices in Africa and therefore cover a wider range of options. They list a total of 160 references, 90% of which were published in the last 20 years. Bouma et al. (2012) adopted a broad definition and identified 300 studies from SSA. Evidence from experimental plots and from farmers' fields appears to show that a range of SWC practices can deliver increased productivity (Bayala et al., 2012), but this has not resulted in diffusion of the innovation to the many farmers who could derive benefit from its adoption (AfDB, 2007; Molden et al., 2007).

This paper focuses on the micro-catchment WH techniques that have been promoted in Burkina Faso, in particular:

- Planting pits (known locally as zaï); typically 20–30 cm diameter, 10–25 cm depth and spaced about 80–100 cm apart;
- Stone lines (known as locally *cordons pierreux*) and earth bunds (known locally as *diguettes en terre*) as contour barriers; typically 25 cm height with base width of 35–40 cm and spaced at 15–30 m apart.

Descriptions of these techniques are readily available in the