Fostering the Adoption of In Situ Rainwater Harvesting for Food Security in Rwenzori Region, Uganda

James W. Kisekka, Nasser Kinaalwa, Evelyne Busingye and Maarten Onneweer

Abstract In situ rainwater harvesting is recognised as a key strategy to improve agriculture production to ensure food security, and several techniques exist that have proved successful in improving soil water storage and fertility. However, widespread adoption of these techniques is hampered by absence of adequate quantifiable evidence of their impact as well as a limited understanding of the determinants of adoption. This paper presents the impact of simple in situ rainwater harvesting techniques and explores some of the factors that led to better adoption of such techniques, based on a case study from Rwambu region in Uganda. It concludes that the adoption of the interventions is affected by current productivity of the land or availability of other land for farming, available resources and their competing uses, labour constraints and past approaches for promoting the interventions.

Keywords Soil water storage · Impacts · Adoption drivers · Land productivity

1 Introduction

Water availability is the major limiting factor to improved crop yields in Sub-Saharan Africa, particularly the absence of water during critical growing stages (Barron and Okwach 2005; Fox et al. 2005). This is due to highly variable rainfall, frequent drought and low water productivity (Critchley and Gowing 2012). A solution lies in managing rainwater on farmer's fields, also known as in situ rainwater harvesting (Ngigi 2003; Vohland and Barry 2009; Critchley and Gowing 2012; Mekdaschi and Liniger 2013).

J. W. Kisekka (✉) · M. Onneweer
RAIN, Barentszplein 7, 1013 NJ Amsterdam, The Netherlands
e-mail: kisekka@rainfoundation.org

N. Kinaalwa
Freelance Consultant, Kampala, Uganda

E. Busingye
IUCN, Kampala, Uganda

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In situ rainwater harvesting has widely been accepted as a solution to increase crop production under water-stressed situations and societies all around the world identified simple technologies to harvest additional water for crops (Critchley and Gowing 2012; Mekdaschi and Liniger 2013). In all cases, these technologies, when properly implemented, positively impact the soil conditions (Ngigi 2003; Vohland and Barry 2009). Particularly in arid and semi-arid areas, the potential to improve and sustain crop production through conservation agriculture and in situ rainwater harvesting and management technologies has received wide recognition (Critchley and Siegert 2001; Ngigi 2003). With the increasing unpredictability of the rainy season, possibly a result of changes in climate patterns at local and global scales, in situ rainwater harvesting becomes even more paramount. Increasingly, there is too much water over a short period of time during the rainy season resulting in flash floods, followed by acute water shortages after the rains (see for instance Osbahr et al. 2011). Knowing this, we find in our work that the replication and transfer of in situ rainwater harvesting technologies is hampered by limited transfer of knowledge from one area to another and limited understanding of their impact, for instance on crop yields (and therefore linkage to food and livelihood security), and what influences uptake by farmers.

In rural development theory, there has been a prolonged debate about the structural factors that make people intensify their agricultural system. The work of Boserup (1965) stands out as the canonical work that described how increasing pressure on the land would actually lead farmers to intensify their agricultural systems, often with in situ rainwater harvesting practices. Since then, it has often been shown how smallholder farmers and pastoralist have successfully applied in situ rainwater harvesting techniques to mitigate the impact of drought, thereby improving production (Tiffen et al. 1993; Fox et al. 2005; Hatibu et al. 2006; Mwangi and Rutten 2012). These technologies include the usual *fanya juu* and *fanya chini* trenches, zai pits, and mulching and stone bunds. In southern Kenya, these technologies were introduced through colonial forced labour, rejected and later picked up again (Tiffen et al. 1993). In some areas of Ethiopia, scale adoption was enforced by food for work schemes or forms of involuntary labour (Descheemaeker et al. 2010). For Uganda, NEMA (2001) reports that various soil conservation technologies (for instance terraces, contours, trenches, agroforestry, and strips of napier grass planted along contours or on terraces) were introduced to control soil erosion in highland areas. Barungi et al. (2013) indicate that the technologies have been promoted by both governments, (through Ministry of Agriculture, Animal Industry and Fisheries (MAAIF)) and Non-Governmental Organizations. However, uptake of the technologies remains low (Barungi et al. 2013).

In 2015, a lack of systematic reviews of literature on the impact of water harvesting technologies on crop yields prompted Bouma et al. (2016) to conduct a meta-analysis of the available literature. Even though Bouma et al. (2016) found that water harvesting causes a significant increase in crop yields, the researchers recommended that more work needs to be done to strengthen the scientific knowledge base. This paper provides more information on the impact of in situ rainwater harvesting on crop yield and also the determinants of adoption of such interventions. In this paper, we provide reference material and inspiration for organizations and individuals looking to promote in situ rainwater harvesting amongst communities and other players. At the same time, we propose that in situ water harvesting is not a one size fits all solution, people and lands are different, even within the same district. Therefore, the replication and transfer of in situ rainwater harvesting technologies needs an understanding of the kind of agriculture people already practice, the possibilities of the land, and the needs and demands of the people.

2 Study Area and Methods

2.1 Study Area

Rwambu is a transboundary wetland separating the sub-counties of Nyabbani and Kijjongo of Kamwenge and Ibanda districts, respectively, in the Rwenzori region of western Uganda (Fig. 1). The area receives bimodal rainfall of more than 1000 mm a year and has a tropical climate. The Rwambu wetland and its catchment drain into

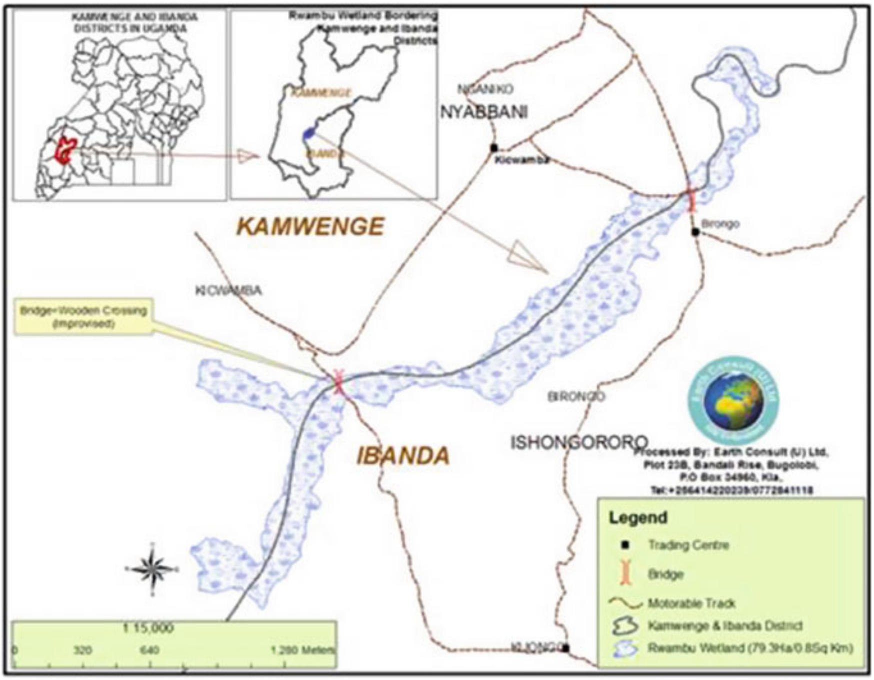

Fig. 1 Location of Rwambu, Uganda

a stream called Rwambu, which drains into a bigger river called Mpanga that in turn drains into Lake George.

Prior to 2012, the Rwambu area faced several interconnected challenges, such as encroachment on the wetland for crop farming, local community reports of reduced soil fertility on the slopes and reduced dry season yield of boreholes. Kisekka (2015) reports as follows how community members described the changes in their community. As population increased, farmers started to cultivate on the hillslopes but without any soil conservation measures therefore leading to soil erosion. Fertile soil eroded from the hillslopes silted up the wetland. As the hillslopes became less productive for crop farming, farmers started to cultivate in the wetland, often saying they were "following their fertile soils". Kisekka (2015) adds that because of increased run-off generation on the hillslopes, the water would rush downhill without sufficiently infiltrating the ground. This resulted in a reduced water table and consequently the drying of springs and boreholes on the hill slopes (Kisekka 2015).

2.2 Methods

In 2012 RAIN, Joint Effort to Save the Environment (JESE), Wetlands International, local governments and communities in the project area, with financial support from the Dutch WASH Alliance, started a pilot project. The pilot aimed to test an integrated approach to in situ rainwater harvesting, wetland protection and water sanitation and hygiene (WASH) service provision at landscape level in Rwambu area. More specifically, it aimed to demonstrate how wetland restoration and management coupled with in situ rainwater harvesting could be integrated at catchment level to sustain WASH. The in situ rainwater harvesting interventions promoted by the project are gathered under the acronym 3R which means that the interventions contribute to recharge, retention and reuse of rainwater. An example can be found on Figs. 2, 3, 4, 5 and 6. The component of 3R technologies aimed to reverse the degradation previously caused by soil erosion on the hilly stony slopes, prevent further soil erosion and improve soil moisture recharge and retention. The 3R technologies implemented include grass strips, *fanya juu* and *fanya chini* terraces and stone bunds. Besides in situ measures, several other technologies such as gully plugs, small check dams and infiltration pits were established to improve water infiltration into the soil.

Fanya juu and *Fanya chini* are earthen bunds made by excavating a trench and making ridge along the contour. To build a *Fanya juu* terrace, soil dug from the trench is put upslope of the trench, and for *Fanya chini*, the soil is put downslope of the trench. Stone bunds, on the other hand, are lines of stones placed along the contour. Stone bunds are usually constructed using both small and large stones (smaller ones placed upslope and larger ones downslope) but can be made entirely of small stones. A grass strip is a row of grass (about 1 m wide) along a contour. The grass can either be planted or be a deliberate remainder when the land

Fig. 2 A farmer stands at a *fanya juu* in a banana plantation. *Photo* James W. Kisekka

Fig. 3 A newly constructed stone bund. *Photo* James W. Kisekka

is prepared for crop farming. The interventions were implemented sometimes using local hired labour but increasingly through voluntary community participation. Table 1 summarises the volume of work per intervention implemented.

Fig. 4 A check dam in a banana garden. *Photo* James W. Kisekka

Fig. 5 A *fanya chini* is a coffee–banana garden. *Photo* James W. Kisekka

Anticipating that the structures would indeed impact ground water levels positively, changes in the groundwater table were measured. Measurements were done periodically in a borehole, which had broken down and consequently abandoned because its yield had dropped greatly over the years.

Fig. 6 A percolation pit in a coffee garden. *Photo* James W. Kisekka

Table 1 Volume of work per intervention

Technology	Volume of work
Tree planting	50,000 and 75,000 m^2 covered on top of the hill and along the wetland, respectively
Grass strips	800 m, total linear length
Grass bunds reinforced with small stones*	40 m, linear length
Percolation pits	10 pits
Fanya juu and Fanya chini bunds	6000 m, total linear length, 4000 m of which collect run-off from roads
Check dams	three check dams, each 12 m long
Stone bunds	4000 m, linear length

Source Adapted from Onneweer (2014a)
*Inspired by complaints from women that big stones (to make stone bunds) were too heavy for them to carry

Further, twenty-seven farmers who had established in situ rainwater harvesting interventions on their gardens were purposively selected for this research. In addition, we randomly selected 14 farmers who had not established in situ water harvesting interventions as a control group and to establish the reasons for not implementing the interventions. The farmers were interviewed in November 2015, using a semi-structured questionnaire.

Farmers with in situ rainwater harvesting interventions on their gardens were asked (amongst other things):

(a) which interventions they have on their gardens (type and extent in terms of metres were applicable),
(b) what was the productivity of their gardens before and after the interventions were implemented,
(c) the main source of labour they used to implement the interventions

(d) challenges they faced in implementing or managing the interventions.

To know which other factors might have influenced crop yields, the farmers were asked to describe how they managed their gardens before and after the interventions were implemented.

Farmers without in situ water harvesting interventions were asked:

(e) if they knew any water buffering interventions (types and main purpose)
(f) reasons for not implementing the interventions.

In addition to the farmers, four key informants (local leaders) were asked their opinion on the determinants of adoption of the interventions in the area. Further information on (changes in) the project area was drawn from reports, publications and online articles by the authors of this paper or their colleagues. This paper also presents farmers' voices as case studies (although farmers' names are not mentioned), with an aim to keep the testimonies original to the extent possible.

3 Results and Discussion

This section describes the implementation of interventions and the actual impacts reached. We then enter into a discussion on the constraints in the uptake of in situ water harvesting. The section closes with a number of testimonies of farmers who implemented in situ water harvesting measures.

3.1 Interventions on Farmers' Gardens

The farmers established either trees, check dams, percolation pits, stone bunds, grass strips, *fanya juu* or *fanya chini* trenches depending on the location of their gardens along the slope. The measures such as percolation pits and check dams could not be positively correlated to crop yields. Farmers have only one or two check dams or percolation pits on their land, and these are often far apart, making it difficult to correlate impact and interventions with reasonable confidence. The project did not combine trees with crops (agroforestry). Therefore, this paper

Table 2 Type and extent of interventions on farmers' gardens

Type of intervention	Number of farmers (n = 27)	% of farmers (n = 27)	Average number per intervention	Average length per intervention (m)
Fanya chini	23	85	4	21
Stone bunds	1	4	8	15
Grass strips	3	11	3	13

focusses on stone bunds, grass strips and *fanya chini* terraces. Table 2 provides an overview of the interventions and the number of farmers who implemented them.

To implement the water buffering interventions in their fields, the selected 27 farmers used project-provided labour, their own labour, hired labour or a combination of own labour and hired labour (Table 3). Project-provided labour and own labour were the highest sources of labour, in equal proportion (37%).

Out of the 10 farmers to whom the project provided initial labour, we learned that 70% of them further replicated the interventions using other sources of labour, mainly own labour (Table 4).

3.2 Impacts

3.2.1 Crop Yields

Of all farmers interviewed, only 4% stated they did not notice a change in crop yields after the in situ interventions were implemented and this perceived lack of impact only applied to the farms where grass strips were implemented. The rest of the farmers observed a 40–60% increase in crop yields depending on the interventions (Table 5). The farmers interviewed indicated that the only change to the management regime of their gardens was the introduction of the water harvesting interventions. Other factors such as the frequency of weeding and fertiliser use remained approximately the same. Therefore, it may be concluded that the difference in crop yields can be attributed primarily to the in situ rainwater harvesting interventions.

The increase in crop yields was caused by improved soil moisture especially during the dry season as well as reduced erosion of fertile topsoil during the rainy season. We found confirmation of erosion (and how to reverse it) at some of the

Table 3 Sources of initial labour

Source of initial labour	Number of farmers (n = 27)	% of farmers (n = 27)
Project	10	37
Own labour	10	37
Hired labour	5	19
Both own labour and hire labour	2	7

Table 4 Source of labour after project support

Source of labour	Number of farmers (n = 10)	% of farmers (n = 10)
Own labour	5	71
Hired labour	2	29

Table 5 Average crop yield improvement per intervention

Intervention	Crop	Number of farmers (n = 27)	% of farmers (n = 27)	Increase in yields (%)
Fanya chini	Banana	10	37	59
	Coffee	13	48	56
Stone bunds	Beans	1	4	60
Grass strips	Coffee	2	7	41
	Beans	1	4	0

stone bunds which were built one metre high but filled up with fertile soil, eroded uphill, in just one rainy season.

Even where the increase in yield may not be substantial, any minimal increase means an extra income to the farmer, provided the cost of implementing the measures is not prohibitive in terms of time. The farmer can implement the measures himself, but if he or she needs to hire labour, then the increment in yields could mean the farmer can have an extra income to pay the labour (if the labour is not too expensive, and usually it is not).

3.2.2 Groundwater Level

Another important impact of the in situ measures in Rwambu was the improved ground water levels in the project area compared to neighbouring villages. At the end of the project implementation, the yield of boreholes and shallow wells in other villages reduced during the dry season of June–September. In Rwambu, the water table increased a total of 2 m in 2 years after the implementation of water harvesting interventions (Onneweer 2014b). The improving water table inspired repairs of and piloting "pay-per-fetch model" on the previously abandoned borehole. Now, the community buys clean water from the borehole at 0.03 EUR instead of buying clean water expensively at 0.15 EUR from water vendors or using dirty water from unprotected springs in the wetland (Kisekka and Busingye 2015b). On another site within the study area, one community member reported: "It has been two years now that my family and the neighbouring households are enjoying the clean water. To my surprise, the well has never dried up. We attribute this constant flow of water to the earth bunds that were constructed upstream of the well to 'catch' the run-off" (Kisekka and Busingye 2015c). Scholars from Ethiopia and Taiwan made similar observations about the increase of the water table due to in situ water harvesting (Negusse et al. 2013; Liu et al. 2004).

3.3 Adoption Constraints

If many farmers describe the impact of in situ water harvesting on crop yields, and a farmer without the interventions can see the results in his or her neighbours' gardens, one cannot help but ask why the interventions have not been implemented on every metre of land in Rwambu. The answer to this question could help to address some of the non-technical problems, such as: under what conditions will people take up in situ water harvesting. The research that led to this paper included a number of questions on the reasons why farmers may not to pick up in situ water harvesting. These questions pertained to knowledge and motivation.

When asked if they knew about in situ water harvesting interventions, all the farmers without interventions on their gardens responded affirmatively. They also mentioned they knew all the interventions implemented under the auspices of the project. In addition to mentioning the type of interventions, they also elaborated on the benefit of implementing the interventions. We then asked why they did not take up the interventions themselves, many farmers stated that they thought the "interventions are too tiresome to implement" (40%), followed by "I am waiting for the project …" which was mentioned 20% of the times (Fig. 7). With the last statement, the farmers meant that they waited for the project to implement the interventions on their farms. The difficulty in implementing a pilot project that aims to demonstrate technologies for which there are too few or no existing examples in the area, from which people can see the results, is that, the project starts with training

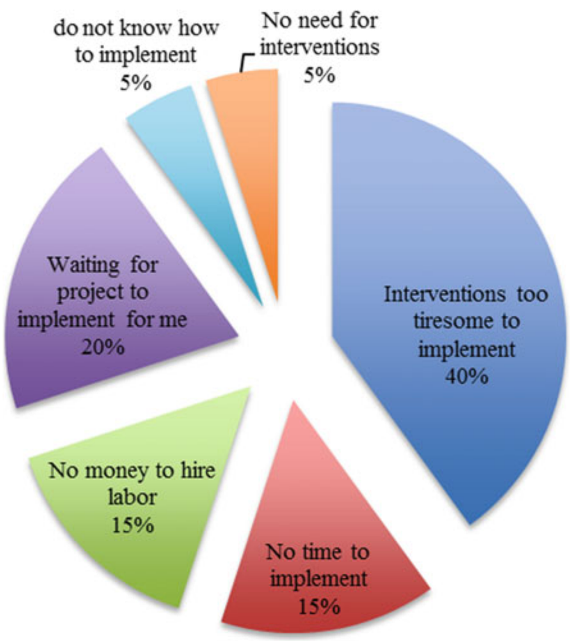

Fig. 7 Reasons for not implementing water buffering interventions

and working with a few farmers to set up demo plots. The aim of doing this is to show what is possible, but then other people become reluctant to implement the interventions, on their gardens, without direct support from the project.

3.3.1 Land Availability Versus Increased Productivity

In support of the Boserup theory of agricultural transition, the next question to be asked is if land availability or increasing pressure on the land causes people to look for means to improve crop yield. Understanding the dynamics of land use, the offset market situation and the options people have for other income becomes more of a determining factor in the uptake of in situ rainwater harvesting (See also Tiffen et al. 1993).

In this context, one of the key informants reported that most of the farmers with gardens on the hill slopes implemented at least one *fanya juu* or *fanya chini* because that is the only way to secure production. Farmers on the lower slopes feel there is no need for the interventions since their gardens are not affected by soil erosion and are still productive. This partially supports the theory that people will look at improving conditions on their land only when there is increasing pressure on the land. In our study area, more in situ water harvesting interventions seem to have been implemented on the steeper slopes.

3.3.2 Labour Requirements

When farmers with interventions on their gardens were asked if they faced any challenges implementing or managing the interventions, 74% responded affirmatively. Two (2) challenges were mentioned: "Interventions too tiresome to implement" and "trenches easily fill with soil" (Fig. 8). These two challenges relate to the labour needed to implement and maintain the interventions.

The farmers noted that making the soil bunds and stone bunds is labour intensive, which discourages many people, but the rewards in terms of increase in crop yields make it a worthwhile investment. Seeing the results, other farmers have started to implement the water harvesting measures on their gardens, either using family labour or hiring youths or other farmers. Trenches are preferred to stone bunds because these are judged not to require a lot of effort to build by farmers.

In only a few cases, farmers adopted stone bunds themselves (so without support from the project), and the general complaint against stone bunds was that they are more tiresome to implement. This applies especially to women, who constitute the biggest labour force. Thus, 4% of farmers were found to implement stone bunds. The trenches (*fanya juu* and *fanya chini*), especially those collecting run-off from the roads and paths, got filled with sediment very fast. The *fanya chinis* on the slopes also easily filled up with sediment. So one of the constraints in the popular uptake of in situ water harvesting for stone bunds was the high initial labour investment. Interventions that require less investment such as the trenches need a lot

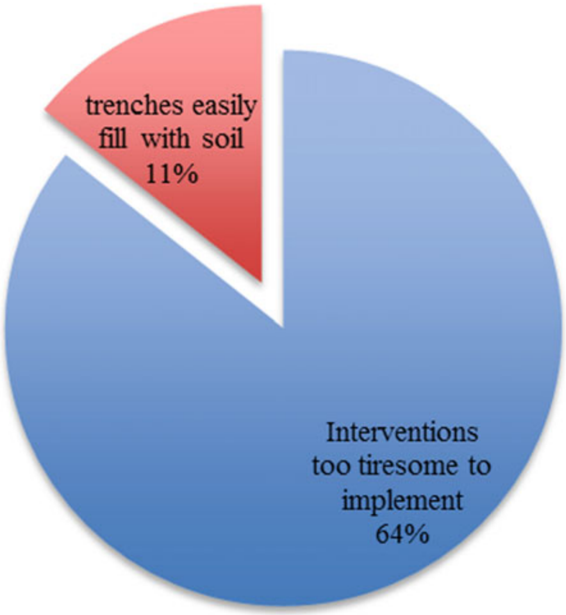

Fig. 8 Challenges faced implementing or managing the interventions

of maintenance to remove the sediment. This discouraged people who have to rely on hired labour because they are either working elsewhere (on and off the farm) or perceive removing the sediment as a strenuous task. Indeed, it is generally known that in situ rainwater harvesting structures require considerable labour costs for their maintenance as mentioned by several authors (Bouma et al. 2016) because heavy rains may damage the structures.

3.3.3 Available Resources

During the interviews, it became apparent that people were more interested in trenches than stone lines. Partially, this was explained by the labour demands and partially because of the limited availability of stones. In the project area, the stones are only on the upper slopes. Also, the high demand of stones for construction (for example of schools and homes) in the villages increased the price of stones, and farmers found it more attractive to sell the stones than to use the stones to make stone lines. Selling the stones gives a quicker source of income. Because the stones are on hill slopes and many farmers live further downward, a competition over stones can be expected.

3.4 Testimonies of Some of the Farmers

Below, we provide six accounts of farmers who implemented in situ water harvesting measures.

3.4.1 Farmer One

Farmer one (male, aged 56 years) is a resident of Rwesigire village, Nyabbani subcounty, Kamwenge district. He reported how yields of beans have increased by nearly 60% on his garden after the stone bunds were implemented. In the garden where beans are grown, there are eight 15-metre stone bunds (five done by the project and three himself). In his words: "I used to plant 8 kgs of beans in quarter an acre and would harvest 40 kgs before these interventions were put in my field, but now I harvest about 100 kgs from the same piece of land yet I still plant about 8 kgs of beans". Because the fertile soil eroded uphill is quickly deposited on (and upslope of) the stone bunds, creating a somewhat level bench, farmer one has been transferring the stones from one site to another aiming to create even more fertile-level benches in his garden.

In addition to the stone bunds, farmer one has other interventions: 500 trees including *Eucalyptus grandis* and *Grevellea robusta*, five 15-metre soil bunds (four done by the project and one himself) and three 15-metre grass strips (all done by himself) (Kisekka and Busingye 2015a). The soil bunds (*fanya juus* and *fanya chinis*) were implemented in the banana plantation. Farmer one reported that the bananas growing close to the soil bunds have bigger stems and give bigger bunches, and because of that, a neighbour hired farmer one to construct three *fanya juus*, each 15 metres, on that neighbour's banana plantation (Kisekka and Busingye 2015a). While farmer one has both *fanya juu* and *fanya chini* trenches, he prefers *fanya juus* to *fanya chinis*, because the former allow water to collect upstream of the ridge and in the trench itself, allowing the water to seep slowly into the soil.

Farmer one indicated that many people are discouraged because making the bunds is labour intensive, but selling his fertile land on the lower slopes (to pay tuition for his children) left him no choice but to cultivate the land uphill and to find ways to keep it productive (Kisekka and Busingye 2015a).

3.4.2 Farmer Two

Farmer two (male aged 43 years) is a farmer in Rwambu IV village, Kijongo sub county, Ibanda District. He has observed a close to 50% increase on the yield of his coffee plantation. On his coffee plantation, there are nine *fanya chinis* (six done by the project and three by a group of youth he hired) of total length 600 m. In his words: "I used to harvest 6–7 bags of coffee (600–700 kgs) from my plantation (before the soil bunds were constructed), but I harvested 13 bags (13,000 kgs) last season, and I am sure to harvest even more this season".

On the same coffee plantation, farmer two intercrops bananas. He reported that the bananas close to the *fanya chinis* have bigger stems and give bigger bunches. He mentioned: "My bananas have bigger stems and yield bigger bunches—instead of the small bunches of about 5 kgs that dominated my plantation, I can now harvest bigger ones (about 15 kgs) for sale". This represents an increase of about 66% in the weight of bananas.

As reported by Kisekka and Busingye (2015a), farmer two indicated that while he hired labour to construct the *fanya chinis,* not all community members can afford that; yet, constructing the soil bunds is a laborious task. According to farmer two, the labour requirement for implementing the interventions and the inability for many community members to afford hiring labour is the main reason only a few community members have constructed soil bunds on their gardens.

3.4.3 Farmer Three

Farmer three (male aged 42 years), a resident of Rwemirama cell in Ibanda district, has 1.5 acres of coffee plantation. There are seven *fanya chini* trenches (all of them constructed by the project) of an average length of 15 m per trench. Each trench covers the entire width of the coffee plantation. In addition to farming coffee, he also buys the coffee from other farmers, de-pulps it and then sells it.

He reports an increase of 40–60% in the yield of the coffee on his plantation. According to his words: "I used to harvest 8–12 bags of coffee from the plantation before the trenches were implemented, but I harvested 20 bags last season, and the coffee is heavier. Previously 100 kg of dry cherries would give around 50–55 kg of coffee beans after de-pulping, but now the beans weigh around 58–60kgs".

He highlighted that constructing the interventions is labour intensive, and because of other competing uses for money, hiring labour is often not a priority. Farmer three mentioned: "For my case, I had to complete constructing the house before I can invest in anything else including making soil bunds".

3.4.4 Farmer Four

Farmer four (male aged 35 years), a farmer in Rwemirama cell in Ibanda district, has 1 acre of coffee. Most of the coffee trees are about 5 years old, but there are trees of 2 years planted. He has grass strips covering about one-quarter of the entire garden, in the middle slope of the garden. There are two grass strips stretching the entire width of the plantation (around 20 m) and also several short strips planted across small gulleys.

Farmer four reports an increase of around 50%. In his words: "One year ago I planted strips of lemon grass to slow running water. Running water erodes the soil and exposes the roots of the coffee, the leaves of the coffee then become yellow during the dry season. This coffee tree was almost drying, I thought it was drying because of bacterial wilt. A small gulley had formed about 1 foot from the tree, and soil had been eroded from the base of the tree. When I put the grass strips the gulley stopped deepening but instead started to fill-up with soil and litter, the leaves stopped drying and now the tree has started yielding coffee. I did not know the gulley would affect the tree that much. I used to harvest 3–4 basins of coffee from each tree per season but the previous season I harvested around 6–7 basins per tree from this section with the grass strips. The yield from the sections without grass strips did not improve much. From the younger trees I harvested 2 basins on average per tree yet the previous season I harvested 1 basin per tree. Together with the neighbours, we use some of the grass as spice for tea, but also I cut the grass and put it in the banana plantation as mulch".

Asked why he has not dug any trenches on his garden, farmer four responded that he is waiting for the project to send the trained-youth to support him and that he has asked the project's community mobiliser several times already. This testifies to the level of donor dependency created in the area, causing some people to become slow at adopting the interventions since they expect external agencies to work on their fields.

3.4.5 Farmer Five

Farmer five (female aged 47 years), a resident of Rwemirama cell in Ibanda district, has two *fanya chini* trenches in her banana plantation, both constructed by the project. Each trench is about 30 metres in length, collecting run-off from the road.

According to farmer five, the size of bunches has greatly improved and the bananas growing close to the trenches have bigger stems. In her words: "The plantation was not productive anymore, but now, from the bananas close to trenches, I can harvest a bunch for sell at 5000 UGX, before I could hardly get a bunch big enough to sell at, 2000 UGX". Taking the price difference as a proxy for improvement of size of the banana bunches, this would represent a 60% increment.

Farmer five mentioned the following: "The trenches get filled with sediment very fast during the rainy season. It takes 2–3 days for me to clean each trench of the sediment, I do it alone at my pace. The main constraint is the labour, especially because all children are either in school or have started their homes".

3.4.6 Farmer Six

Aged 29 years, farmer six is a farmer in Rwambu 4 village, Ibanda district. In his 0.75-acre coffee plantation, there are four *fanya chini* trenches (one done by the project, three jointly by him and his wife) each 25 m in length covering the width of the plantation. He reported a 66% increase in the yield of coffee on his plantation.

"I harvested 1.5 bags of coffee last season, before it was 0.5 bags. I expect around 3 bags this season".

Farmer six indicated that many people find the trenches labour intensive to implement themselves, and yet, they do not have enough money to hire labour.

4 Conclusions and Recommendations

This paper adds to growing evidence that in situ rainwater harvesting has the potential to increase crop yields. It showed how in the case of the Rwambu area, the entry strategies of the project play a role in the uptake and that it can be determined by past approaches of other extension agencies. Particularly, the presence of more agencies (that give free services to communities) has made people reluctant to adopt the interventions while the project is still ongoing.

The Rwambu area saw a large population increase, and for some people, this meant an increased pressure on land availability. We conclude that, confirming partially the Boserupian theory of agricultural growth, the pressure on land motivated people to implement in situ water harvesting to increase production. Their efforts pertain particularly to lands that were not yet under permanent agriculture; so particularly, when people look for new arable land, the low productivity and high erodibility start to become a key driver in uptake as people are left with less land on the lower slopes. The reduction of available land, for whatever reason, can cause rapid change in land management systems. Other external factors that influence the possible uptake include current productivity of land; if farmers consider their lands as already productive, then the added value of in situ techniques will not be seen easily. From the responses of key informants and the farmers, as well as our own observations, in situ rainwater harvesting has not only impacted on crop yields, but has also led to improved ground water levels. However, we feel there is a need to collect more data to verify and support these observations and testimonies, using controlled plots and experimental designs, where different parametres are monitored over time.

The academic discussion on the impact of in situ water harvesting revolves around the technical impact and the outcomes of longer socio-economic trajectories. The focus on the actual project procedures and actual farmers looking to increase their production at minimal expenses brings in a dimension that is less well understood. We feel it is critical to add this dimension to build up understanding of the success and failure. Unlike the government-driven interventions in Ethiopia, many developing agricultural economies depend on small-scale initiatives for the implementation of in situ water harvesting; so now that we established the positive results of in situ rainwater harvesting, we should question the distribution and uptake mechanisms.

We propose that the real push towards improving agriculture to ensure food security is in popularizing small-scale water harvesting methods and technologies adapted to the socio and biophysical environment of a place. With popularizing, we mean two activities, first, local extension agencies (government and/or non-government) need to promote best practices based on knowledge and capacities of the farmers, but also of structural aspects contributing to uptake such as pressure on land, market prices and other potential sources of income. Second, the introduction of new ideas and improvements should always be based on an assessment of the technologies that can be picked up by local communities, adapted to local conditions for maximum and long-term positive socio-economic and environmental impacts, and easily scalable by farmers. According to Cole et al. (2013), such a 'human-centred design' implies a dynamic trial and error method in which understanding the determinants of adoption is part of the learning cycle of the project.

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