Rainwater Smart Agriculture for food security – Case study of Piloting Rain Water Harvesting and Community Based Climate Change Adaptation Planning in 3 Districts of Rwanda.

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Abstract

Although rainfall is plentiful in the central and southern highlands of Rwanda there are water shortages for an average of 90 days in the dry season. The steep slopes, which are cultivated up to three times per year, are subject to high levels of run off and the valley bottom water bodies suffer high levels of siltation. Women and girls carry water from these valley bottoms in the dry season and the higher levels springs are becoming less enduring due to land degradation and erosion. Since early 2015, Trócaire in collaboration with four local partner organisations, has been piloting Rainwater Harvesting Technologies for capture of rainfall from household rooves and from footpaths between fields. A variety of collection, storage, and lifting systems are being tested by over 753 individual households and 374 members of farmers' cooperatives. This paper describes the water dynamics in four catchment areas, the site surveys, and the criteria for matching household circumstances with different collection and storage systems and the systems themselves. Cost-saving by using bamboo reinforcement in storage tanks instead of steel reinforcing bar and by building semi-underground storage tanks rather than fully over ground storage tanks is a feature of these trials.

Key words: *Rainwater harvesting, water technologies, community water resources management.*

1. Introduction

Rwanda is a small, landlocked country, 26,338Km^2 with 11.5 million of population, and annual population growth of 2.76%. It is one of the poorest countries in the world, ranked 163 on HDI, with 39.1% of the population living below the poverty line of 2$ a day, women being the most affected. The country's economy is highly depend on agriculture, where 87% of the population depend on subsistence agriculture for their livelihood, with limited income alternatives. This results in limited access to land resources where the average land size per household of 5 people is 0.5ha, and becomes one of the biggest challenges that people face for their livelihoods. Pressure on other natural resources is also seen through environmental degradation as a result of overexploitation and improper use of natural resources especially land and water resources.

Precipitation is the main source of water for agricultural production and generally the country has sufficient rainfall with 2 rainy seasons throughout the year. Unfortunately, about 4.3 km^3 of rain water is lost as runoff water every year and causes soil damage. For various reasons, including limited water storage capacities, less than 2% of the available rainwater resource is used. This situation is compounded by the impact of climate change on the country which is leading to different shocks and disasters such as floods, landslides, dry spells, and risks of crop losses.

To address the above mentioned challenges, rainwater harvesting has been identified as one of the strategies toward Integrated Water Resources Management, with its double advantage of contributing to improve water availability and to mitigate the hazards related to excess runoff and environment destruction. The Government of Rwanda recognizes that Integrated Water Resources Management has a central place in achieving the poverty reduction and economic transformation goals, outlined in the Vision 2020, EDPRS II and various sectoral plans (MINIRENA 2013). The promotion and adoption of Rainwater harvesting (RWH) is one of the key outputs under the Water Resources Management policy, seeking to ensure efficient and sustainable use and conservation of water. At national level a RWH strategy has been developed.

This paper describes the piloting of Integrated Water Resources management (IWRM) with a focus on rain water harvesting technologies by the *Water for Agricultural Production Project* funded by the Scottish Government and implemented by Trócaire Rwanda in partnership with SCIAF through 4 local partners namely IFPG, UNICOOPAGI, COCOF and MMM Kirambi.

This was done through community education in climate change adaptation, dissemination of low cost technologies in rain water harvesting and the development of community-based climate change adaptation plans. In order to upscale and sustain the achievements from the pilot phase, manuals focusing on the management and maintenance of the different rain water harvesting technologies were developed and local communities were trained. In the following sections, the paper explains the methodology used for the project implementation, the project experience on rain water harvesting technologies, the lessons learned and challenges encountered during the last 36 months of the pilot phase. The paper ends with conclusions and recommendations.

2. Methodology

2.1.Project Area Profile

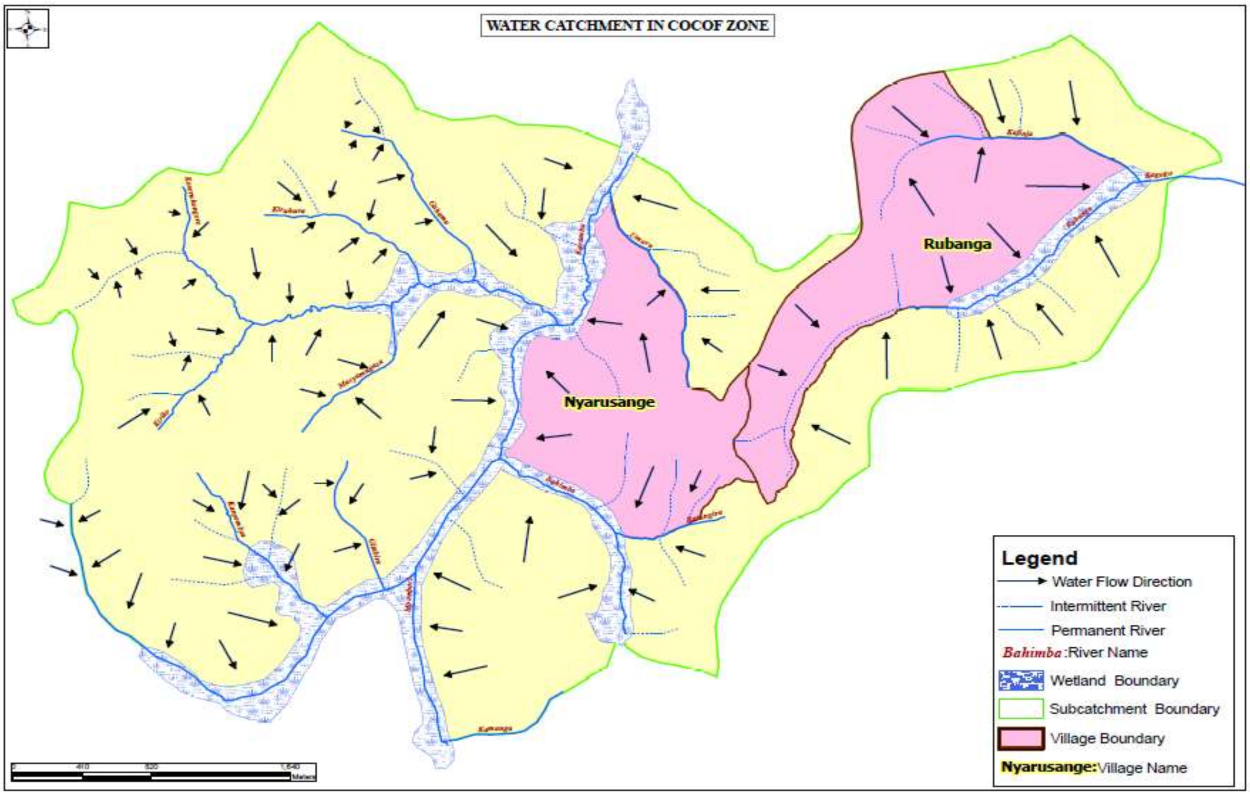
The geographical coverage of the project was chosen with priority to the poorest Districts in Rwanda and covers three Districts of the Southern Province namely Nyanza, Nyamagabe and Kamonyi. Nine villages from the above mentioned Districts were chosen to pilot the technologies. Communities from these villages depend on agriculture for their livelihoods but don't have enough water to help them boost their agricultural production during the dry season. The scope of the project is limited to Rubanga and Nyarusange villages in Kamonyi District, Gikomero, Gatare, Nyarugeti, Ngororero and Uwinyana in Nyamagabe District and Bweru and Mpaza villages in Nyanza District. The altitude ranges between 1,300 meters and 2,700 meters, Nyamagabe being the highest. All villages have steeply sloping topography, although there are differences between the four areas (See topographical maps 1, 2 & 3 showing hydrological features). All the villages experience a short rainy season from September to November and a long rainy season from February to May. The short dry season runs from December to January and the long dry season from June to mid-September. The annual rainfall varies from 1200 to 1450 mm and average temperature ranges between 17 and 20 degrees Celsius, Nyamagabe being the coolest and Kamonyi the warmest. Crop farming and animal husbandry are the main economic activities. Other activities such as commercial activities and construction manpower are done by a small number of households.

During the baseline study, by the community members in a participatory manner, of 122 households (HH) using the Ministry of Finance's *ubudehe* system of poverty classifications, approximately half of the sampled households are classified as 'poor' and are in Category 1 of national *ubudehe* classification, while 38% are 'very poor' and 10% are in 'abject poverty' and are in Category 2 of national *ubudehe* categorization. The majority of plot sizes per household are in the range of 0.61-0.85 hectares. Approximately 75% of households possess either poultry or other livestock. The most common source of energy for cooking is wood. Although government statistics show that Rwanda has turned around the trends in deforestation (REMA 2015), there is evidence of water resources degradation due to the removal of woody species. Trees and shrubs are cut and crop residues are used for fuel such that soil is exposed to erosion due to extreme shortage of fuelwood especially in Kamonyi. Changes to cropping such as the substitution of bananas by root crops such as Irish potatoes and cassava/manioc have led to a comparatively higher level of soil disturbance at harvest of the root crops which has increased erosion in agricultural lands. Pressure to produce adequate food and cash crops means that three cultivations of the land take place each year thus loosening soil structure, increasing evaporation and increasing vulnerability to erosion. During a baseline survey done by Trócaire in January 2015 across the villages targeted by the project, most (85%) of the 122 households (60% Female Headed Households (FHH) and 40% Male Headed households (MHH) testified that they know about the climate change phenomenon. A proportionate stratified sampling technique was used to collect information on water resources and climate change from households within the study areas. Using a sample frame, a sample size of 15% households was drawn from the total target population of 802 households. A large number of residents (73%) cited observation of nature as their source of information on the climate change phenomenon. More than half (58 %) attribute climate change to religious reasons “God’s wish, or God’s punishment due to human being sins”. 30% of the respondents could not explain what causes climate change, and a few respondents (11%) attribute the climate change phenomenon to deforestation, ozone destruction and industrial pollution. The respondents said unanimously that the climate change phenomenon is illustrated by change in rainfall patterns, unpredictability of rainfall patterns, change of seasons, unpredictable decrease/increase of amount of precipitation and periodic dryness. The respondents cited starvation, poverty, water shortage and natural catastrophes (floods, erosion) as the main consequences of the climate change phenomenon. For climate change adaptation the majority of respondents (92%) claimed to have done anti-erosion terraces and planted anti-erosion trees and bushes.

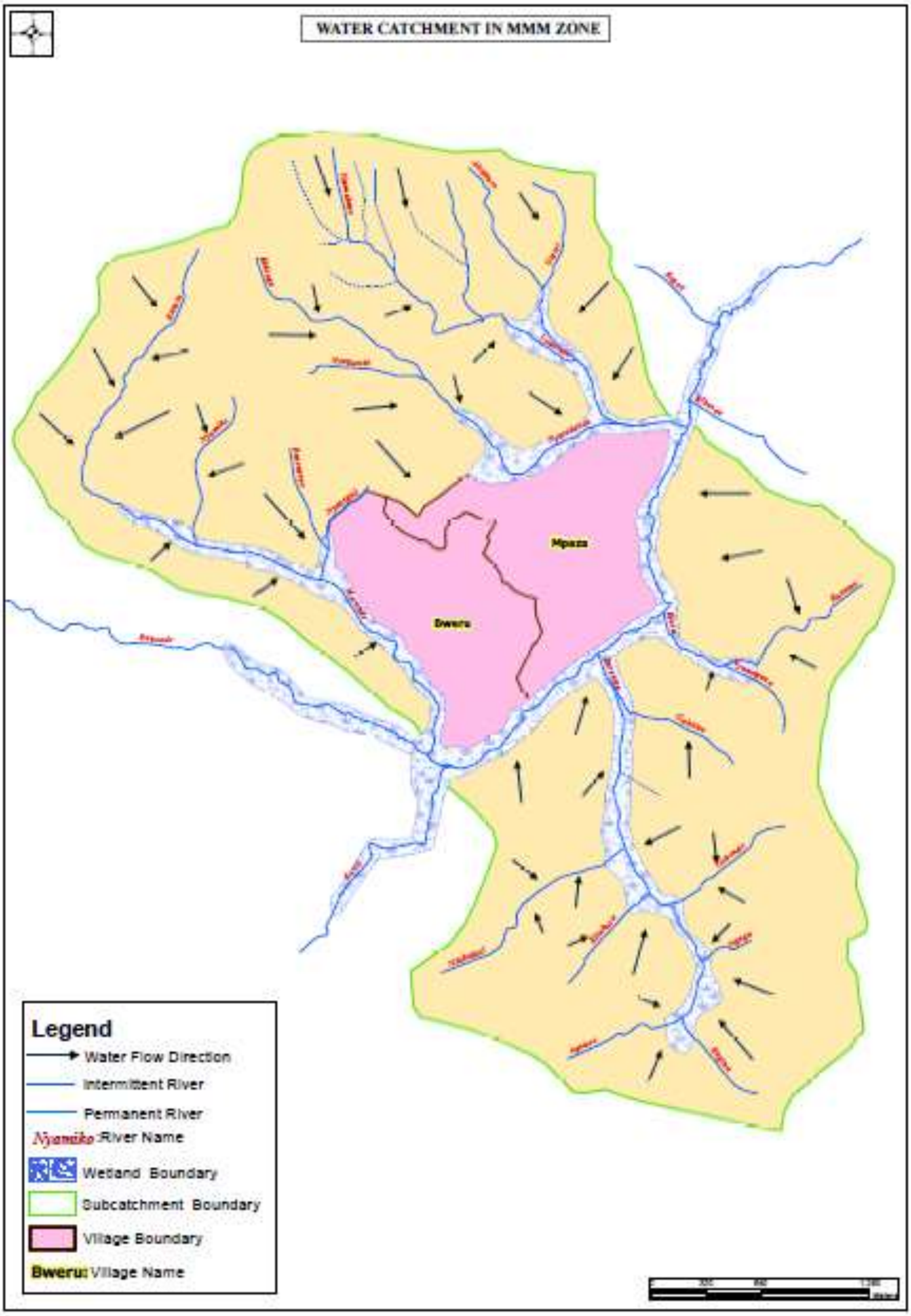
The baseline survey found that some traditional rainwater harvesting is practiced. For example in Nyanza it was found that the traditional rainwater harvesting technique is very poor in both the catchment (roof) and the storage system (no conveyance system such as gutters and conveyance pipes). This practice consists of manually collecting rainwater from a roof using small and removable home containers such as pans, drums, bowls and pots. The absence of a conveyance system does not allow the collection of a sufficient amount of rainwater. Mostly households were not aware of the phenomenon of storing big volumes of water to be used for an extended period. However, for daily usage, rainwater is stored into domestic containers such as jerricans, pans, pots, bowls and drums. As indicated before, wastewater is not well managed and used except some households which use kitchen waste water for watering pigs and for gardening.

2.2.The catchments

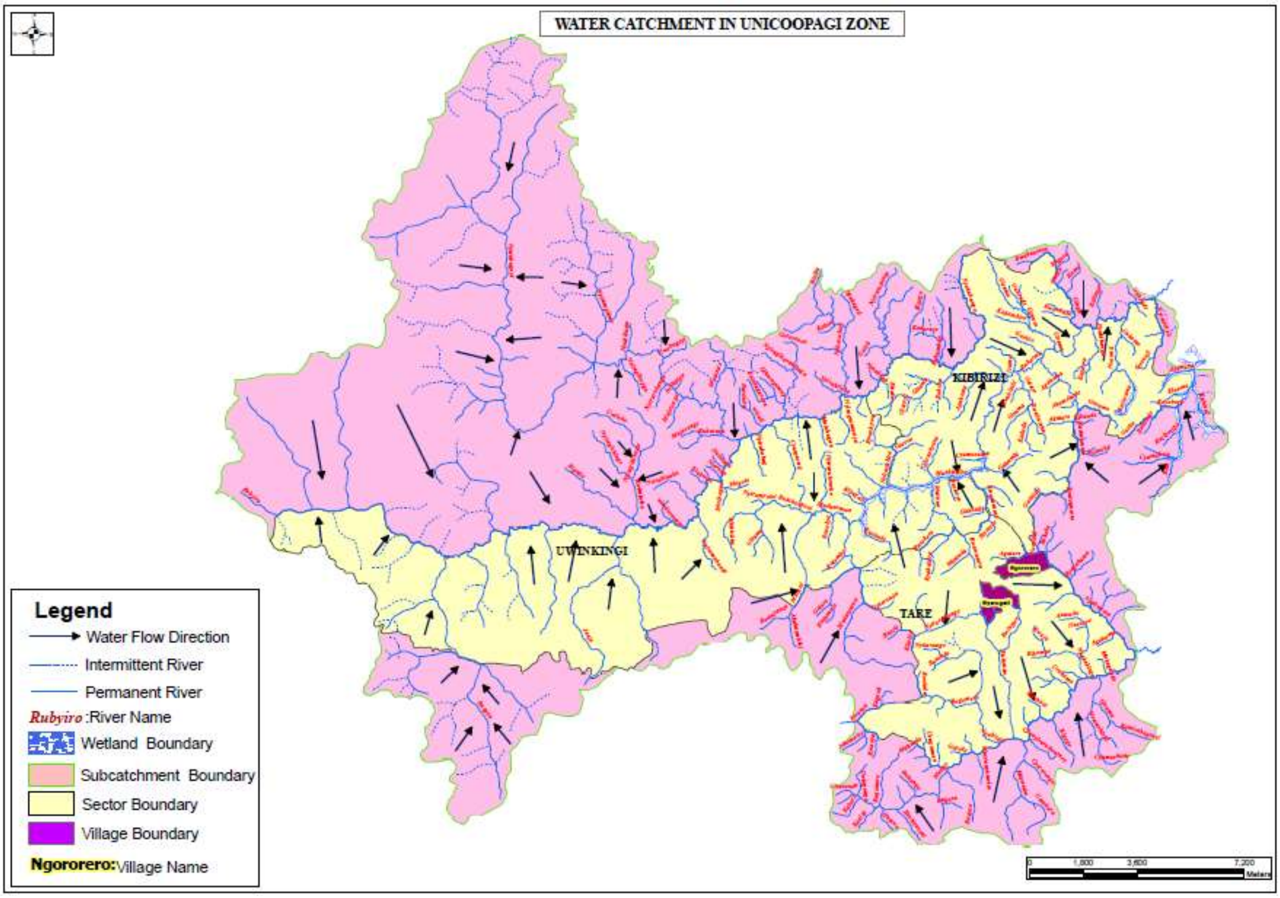
The 9 villages are located in four catchment areas which comprise agricultural land (over 75%), forests (approximately 16%), human settlements (less than 6%), and water bodies (over 3%). Like most cases in Rwanda, in these catchments, rainfall is distributed seasonally in two rainfall periods. The amount of rainfall collected in these catchments area should be big enough for both agriculture and domestic uses. However, there is no suitable technique for harvesting enough quantitatively and qualitatively. For agriculture purposes, runoff is not well directed and collected in the structures which could keep it in the soil and improve soil moisture. Most cases where runoff is not well harvested, it causes erosion and therefore environmental degradation. However, some practices such as bench and progressive terracing, tree planting and road canals have been introduced to handle this issue. Human activities such as natural resources exploitation (farming, mining and quarrying, human settlement, deforestation) have caused natural resources degradation as they were not well designed. Generally, the existing green areas (forest and vegetation) in these catchments are legally protected under regulations from local authorities.



Map 1: Topographical map showing hydrological features in Rubanga & Nyarusange Villages of Kamonyi District.



Map 2: Topographical map showing hydrological features in Bweru & Mpaza Villages of Nyanza District



Map 3: Topographical map showing hydrological features in Nyarugeti & Ngororero Villages of Kamonyi District

2.3.Water situation in the targeted districts

Recent government domestic water access data is available for each district under the Integrated Household Living Conditions Survey (Enquête Intégrale sur les Conditions de Vie des ménages EICV3) (National Institute of Statistics of Rwanda, 2012). For example Nyamagabe, which is ranked worst in terms of poverty with 73% of its population identified as poor (including extreme-poor), is 17% below the Economic Development and Poverty reduction Strategy (EDPRS) national target requirement for the water and sanitation sector, which aims to increase access to safe drinking water to 85%. The EICV3 results indicate that 68% of Nyamagabe district households use an improved drinking water source (protected springs, public standpipes, water piped into dwelling/yard, boreholes, protected wells and rainwater collection, as defined by the World Health Organisation). In Nyamagabe district the majority of households use protected spring water (51%), followed by a public standpipe

(8.5%) and protected well (6.5%). It is important to note that 32% of households still use unimproved water sources. More than a third (36.5%) of households in Nyamagabe district are within 15 minutes' walking distance of an improved water source and it is also important to note that 16% of households still walk 30 minutes and above to reach an improved water source.

Trócaire baseline survey in the project areas, found that only 13% households have their nearest source of water at a distance less than 100 meters; 28% households have their nearest source of water between 100 meters and 500 meters, and more than 59% households have their nearest water source at a distance greater than 500 meters. Water sources included groundwater aquifers / springs, wetland/marshland, rivers/streams and limited piped networks before the project implementation. Only 7.4% of surveyed households have an improved water source. This is far fewer households than the average figure of 68% found by the EICV3 survey. Rainwater harvesting was introduced at the project's inception.

Table1: Domestic water sources. (Trocaire a, 2015)

Project geographical area	Water sources					
Villages/Districts		**Sample size**	**Ground water aquifer/spring**	**Marshlands**	**Rivers/ streams**	**Network of potable water**
Rubanga and Nyarusange Village in Kamonyi District.	FHHs	13	8	6	1	3
	MHHs	10	7	6	0	5
Gikomero and Gatare villages in Nyamagabe District	FHHs	14	8	10	7	0
	MHHs	10	6	9	5	0
Uwinyana & Nyarugeti villages of Nyamagabe District.	FHHs	27	21	11	0	1
	MHHs	19	16	7	0	0
Bweru and Mpaza villages of Nyanza District.	FHHs	19	10	14	11	0
	MHHs	10	4	6	7	0
Total in percentage			65.57%	56.56%	25.41%	7.38%

2.4.Project approach and description

The Water for Agricultural Production Project is funded by the Scottish Government through the partnership between Trócaire and the Scottish Catholic International Aid Fund (SCIAF) and aims at integrating technologies and practices in rain water harvesting and waste water management in order to boost agricultural production and increase the climate change resilience of small scale farmers.

The project's overall objective is: "*Targeted households have resilient livelihoods as a result of increased knowledge and capacity in water resources management, technologies and practices*. "

Five project outputs were planned;

1. Households in 9 communities are educated in climate change adaptation practices and planning.

2. Roof water harvested and used for vegetable production by FHHs and MHHs.

3. Run-off water harvested and used for agricultural production by FHHs and MHHs.

4. Household wastewater recycled and used for vegetable production by FHHs and FHHs.

5. *Climate Change adaptation technologies and practices in 9 communities are documented for internal and external learnings*.

This paper focuses mainly on outputs 2 and 3 which relate to Rainwater Harvesting.

The project activities included the identification of the most vulnerable households and groups for runoff ponds; a whole-village water resources survey; a rainwater harvesting survey to match houses and sites to appropriate technologies; community education and organisational skilling about water resources and climate change.

2.5.Community education in climate change adaptation practices and planning

Figure 1 below outlines the process of engaging with communities to assess their water resources and prepare community water resources management plans.

Firstly, householders were provided with training in climate change adaptation. Secondly, villagers were asked to establish Community Climate Change and Water Committees for the implementation and monitoring of the climate change adaptation plans. Thirdly, villagers developed a village water resources map, followed by a transect walk to validate the key points which helped them to develop a vulnerability matrix. Water field officers were recruited and trained per pair of villages in order to facilitate the villagers' engagement and training throughout the project. A stakeholder's workshop has been organized as well to facilitate the villagers share their findings and expectations with local authorities and decision makers.

Key Steps taken to Prepare for Community-Based Adaptation Plan

Step 1: Discuss climate change impacts with a particular focus on water resources

- The impacts the villagers already see
- The impacts the scientists forecast for Rwanda
- Explanation of Climate Change adaptations, Rwandan NAPA and the priority of Integrated Water Resources Management
- Request for villagers to elect the Village Climate Change and Water Committee

Step 2: Assess opportunities, capacity, vulnerability and risks by developing a map

- Prepare village Climate Change and Water Committee in developing the village water resources map
- Mapping of village water resources by villagers facilitated by Village Climate Change and Water Committee
- Transect walk to validate key sites identified on the map
- Assess water resources management capacities (individuals and organisation)

Step 3: Analysing water resources issues and opportunities and prioritising actions

Step 4: Making a Water and Climate Change Adaptation Plan

- Key areas to focus on: Erosion control; protecting vulnerable zones; run off rain harvesting; clean water supply etc.

Step 5: Implementing priority actions relating to water resources management

- Implement agreed actions in the Village Action Plans
- Formalise the village water resources management organisation

2.6. Site assessments and data collection for rain water harvesting technologies

An assessment was conducted by consultants in the 9 project villages to gain a better understanding of the technical feasibility; cost effectiveness and replicability by the local population of the proposed technologies (Trocaire, 2015 a). Study visits were made to areas where these technologies have been applied and proven successful.

The site assessments were done following two specific objectives;

- To identify issues relating to water needs for the households (domestic, gardening, sanitation, livestock etc.)
- To measure roof size and describe types of roofing materials.

. The rainwater survey studied 406 households situation of the households identified as neediest. For this purpose, a checklist was established (See Annex 1), with a specific focus on physical and social criteria such as roof size and type, negative interaction with the surrounding environment (erosion, flooding, structures destruction), availability of rainwater tanks, water need, source of potable water, contribution to RWH project implementation and accessibility to the site. Measurements of roof sizes (0 to 25m^2, 25 m^2 to 70 m^2 or over 70 m^2) were done together with an evaluation of the roofing materials (tiled or iron sheet) and land suitability for construction.

2.7. Tank sizing

In deciding size of the tanks two methods were used; the “method of scarcity period” and the “cumulative method”.

Method of Scarcity period: This method is mainly used where the rainfall is very short (especially in dry areas) and the water demand cannot be covered regularly by harvested water in the tanks. However, even if the rainfall is not short, the same method was used as the volume of water flow from the roof was too small given that the household’s assessment indicated that 90% of the households are tile -roofed[1]. This method consists on the determination of water scarcity period which means rain distribution through year. In the project area, this period is for 90 days (July-August-September) and the tank sizing has been done taking into consideration household water demand during this period and an estimation of the total volume of water that can be harvested yearly from the rooves.

[1] Clay tiles absorb high volumes of water and thus provide less runoff water than iron sheeting.

The potential collected rainwater on roof area will be given by the following equation:

V= PxRCxS

Where:

V= volume of potential collected rainwater (m^3)

P= Annual Rainfall (mm)

RC= Roof coefficient

S= Roof surface area (m^2)

Cumulative method: this method is suitable with the regions where the rainfall is enough and regular (case of our region) and the roof runoff coefficient[2] is high enough to collect big volume of water. Following are the procedures to estimate the capacity of a water tank able to supply sufficient water throughout the year for a family:

- Determine the water demand for each month;
- Decide catchment area/areas from where rainfall is going to be harvested;
- Obtain average rainfall data from the nearest meteorological station, at least 10 years record;
- List rainfall data sequentially starting from the month with highest rainfall record;
- Decide the runoff coefficient based on the nature of harvesting surface or catchment area;
- Compute the amount of runoff that can be collected for each month;
- Calculate the difference between cumulative volumes of water harvested and total demand per month
- If the difference between the supply and demand is positive there will not be water shortage during the year. Thus, design will be chosen depending on the maximum volume of water, the difference between the cumulative water harvested and cumulative water demand.

[2] The runoff coefficient determines how much water will flow from the catchment surface when it rains and how much get lost. A coefficient of 0 = 0% runoff, a coefficient of 1 = 100% runoff

Seasonal rainfall data and the runoff coefficient, which determines how much water will flow from the catchment surface when it rains and how much gets lost, were used in calculating the potential volumes which could be collected. Potential demand for domestic and irrigation needs were calculated and tank type and size was matched to that need.

2.8.Tank design

Apart from the roof size, roof type, rainfall availability and water demand, other factors such as available space for infrastructures, available low cost materials and soil structures were also taken into consideration for the tank design. For example, for small tiled rooves where low volumes could be collected, it was decided to provide semi-underground tanks which have their own iron-roofed catchment in order to boost the volume of water collected.

Three types of tanks were chosen for individual households: - semi-underground tank, bamboo tank and plastic/polythene tank. Ferro cement tanks were not chosen because they were as expensive as plastic tanks and could be replaced by bamboo tanks for a much lower cost. Runoff sites were also identified to provide groups of farmers with large volume poly-lined irrigation ponds.

Each infrastructure was fitted with other necessary parts such as plastic conveyance pipes, outlet taps, gutters, first-flush filters, down pipes, pumps, joints and recharge trenches.

Table 2: Technology choice and comparison

Water Technology Type	Comments	Construction steps
Polyethylene Water Tank 	• The estimated price for $5m^3$ tank is 900 USD • Plastic; can be moved from one place to another without damages • Materials not found locally • The price varies according to the tank size • Doesn't require much space	-Quick and easy as they are bought already assembled. - Gutters are attached to the roof of the house which lead to a filter at the top of the water tank where the rainwater can infiltrate into the body of the tank. There is a pipe at the lower end of the water tank which can be opened/closed to release the harvested rainwater.
Bamboo Water Tank 	• The estimated price is 600 USD for $5m^3$ and 900 USD for $8m^3$ tank • Made at the site using local materials • There is an abundance of Bamboo in Rwanda, it also grows relatively fast • Cheap to make compared to polyethylene tank • Doesn't require much space	- A site near the house was selected, cleaned of debris and levelled. -A layer of sand was compacted and concreted. -A layer of concrete mix with cement, sand and coarse aggregate was placed on the base. -The bamboo reinforcement cage was placed in position and concreting of the based was completed. -Accessories such as scour pipe, outlet pipe and overflow pipe were installed. -Plastering was done in two stages starting from the bottom.

Semi-underground Water Tank 	• It is very low cost compared to the Bamboo and Polyethylene tanks, the estimated cost being 300 USD for $6m^3$ and 367 USD for a $10m^3$ tank. • It is easy for local population to replicate as nearly all raw materials (with exception of iron sheets and lining sheeting) are made locally. • Already 9 HHs in 3 different districts have undertaken construction of these tanks using their own financial resources.	-These tanks are constructed following the steps for building a small house with a hallow floor with a plastic sheet covering part of the inside where the rain water is stored. -A window is added for cleaning purposes and -Accessories (pipes, pump) are added for water capturing from the rooves and water lifting for usage. -A roof is also provided for hygiene and protection purposes -A local very simple fabricated pump is added to lift the water
Water Run-off Pond 	• Can irrigate a large area of land • Expensive to construct (but shared by several households) • Most effective in farmers cooperatives due to high capacity for irrigation • The estimated prices varies between 2,900 USD for $250m^3$ and 4,300 USD for $480m^3$ and plus for the big sizes. • Appropriate for the big plots and not applicable at individual household level	-Site selection close to the command area, with no hard rocks, the site should allow the pond to receive much runoff and avoid to the maximum any type of accident. -Excavation is necessasy -Covering the hole with a plastic sheeting -Construction of water drains and silt trap -A pump is needed for watering -Fencing for security and safety.

In total of **161** bamboo tanks of 5,000 to 8,000 litres volume per unit, **22** polyethylene tanks of 5,000 litres volume per unit and **570** semi-underground tanks of 6,000 to 10,000 litres volume per unit were installed at **753** households. Twelve poly-lined runoff water ponds with 480,000 and 250,000 litres capacity were constructed with farmers in cooperative groups. The project covered all external material and technical costs while the householders and groups contributed with labour and local materials. Delivery from the bamboo and plastic tanks is by gravity but EMAS[3] pumping systems were installed with the semi-underground tanks and foot pumping systems are being tested for the ponds. Community members were trained in construction and maintenance of the technologies and provided with tools for maintenance. Training was also given in gardening using the collected water as the purpose of the project was to help villagers improve their lives by using the rain water harvested for vegetable production.

3. Results and discussion

Nine communities participated and successfully tested the technologies. As a result, 753 households (298 MHHs & 455 FHHs) installed one or two technologies and are now harvesting and storing the rain water for their farming activities, mainly homestead vegetables production... Findings from an internal survey show that vegetable production is 1.8 to 2.9 times greater for 753 HHs with rain water harvesting tanks compared to the control group not supported by the project within the same communities (Figure 1).

Additionally, 374 Households (231 FHHs & 143 MHHs) grouped into farmers' cooperatives installed 12 run- off water ponds with 480,000 and 250,000 Litres capacity to irrigate their group plots (17 ha). This has reduced strongly crop stress usually observed when the rain stop earlier than anticipated.

Training on installation and maintenance of kitchen gardens was a fundamental component of the project to ensure the harvested water was used for vegetable production at household level. Previously, many households had not used kitchen gardens and most had not used harvested rain water for irrigation purposes. The seeds and training on how to effectively use these seeds, along with knowledge in ecologically sustainable farming practices i.e. mulching to reduce

[3] The EMAS pump (also called the EMAS Flexi pump) is a very cheap PVC piston pump for family use, which can both pump water from a well and pump it to an elevated point.

evaporation loss and slow infiltration rates; improved watering techniques helped improve production levels. Project participants mentioned that the harvest from their kitchen gardens is much greater than from the traditional methods.

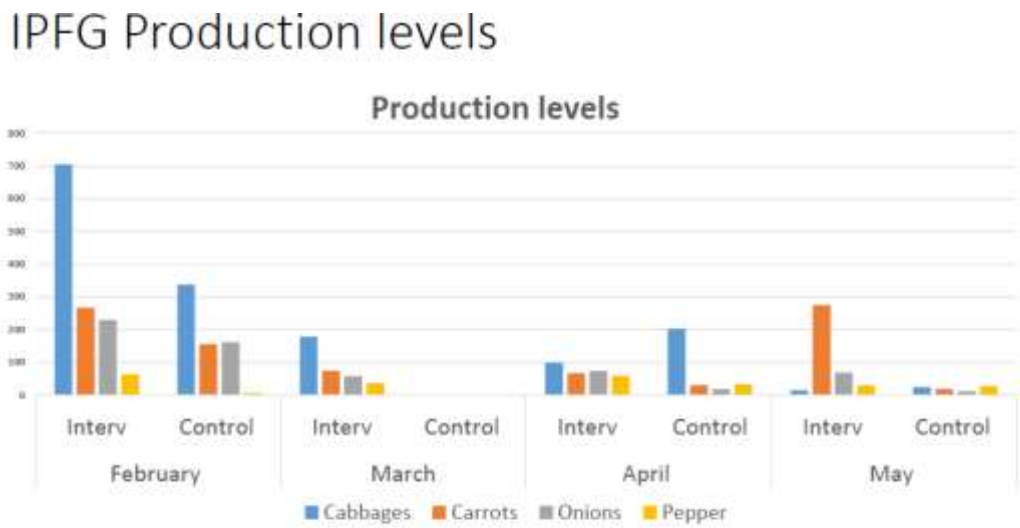


Figure1: *An example of the comparison between vegetable production by project participants Vs non participants in the same area in Nyamagabe District; chart produced by Trocaire M&E Officer during the vegetable production analysis for the period from February to May 2016.*

Finally, eight communities have developed village climate change adaptation plans and established Village Water and Climate Change Committees (VWCCs). The VWCCs have presented the findings of their village water resources investigations to higher authorities. Having brought various issues to the attention of the authorities, they have received some immediate responses from higher government decision makers. As a result, two of the 3 Districts have included the rain water harvesting among the key priorities in their Development plans following the results from the pilot phase. Informal mining has been suspended in one village and budgetary provisions will be made for repairing a piped water system in another village.

Mind-set change has been achieved at both village and higher governance levels. Villagers realise that they have power to change the management of communal water resources and factors affecting them. Higher government has opened its eyes to some very serious problems relating to water resources, soil erosion, floods and dry spells and are willing to act. Higher authorities are grateful to villagers and to the project for establishing and training the Village Climate Change and Water Committees and for making climate change adaptation plans.

Higher authorities are very happy at the speed, quantity of infrastructures in place and quality of their installation to promote the rainwater harvesting systems as this is part of the government's plan and priorities.

Following the experience from the pilot phase, other NGOs have copied technologies in other villages within the same Districts. Examples from Kamonyi District are that the district is going to copy the project in 12 other Sectors (administrative units in Rwanda) using the national climate change fund, FONERWA, which receives international donor contributions.

3.1.Project sustainability

The project has promoted ownership by communities and local civil society partners which enables the continuation of project activities after the project end. Four implementing partners have a well-established presence in the project's target communities, and will continue to provide ongoing technical support to the community members.

The project sustainability and impact has been ensured also through trainings on installation and maintenance of kitchen gardens for vegetable production, training of project participants' local technicians, publishing a manual about the management and maintenance of each technology and by establishing a community based maintenance and reparation fund in each of the project sites. Savings are realised on regular basis to increase the capacity of the fund established and will be used for the repair of the technologies if damages occur. There is a water and climate change committee elected by the members in each of 8 villages working as catalysers for the management and maintenance of the tanks established together with the implementation of their community based climate change adaptation plans.

3.2.Key Lessons

1. Success from the project was driven by the following:

   - Trócaire and partner staffs' openness to the new whole-village, catchment -wide approach. They had previously focussed on on-farm and cooperative activities with individual households selected for their household vulnerability and poverty. This was a new approach which went wider-than -farm and considered whole village communities and their catchments.
   - Strong trusting relationships between the partners and the villagers and between Trocaire and the partners.

- The placing of water technologists in partner organisations and with responsibility for facilitating only two villages each. The technologists were able to provide day-to-day technical and organisational advice and support to the householders and the village community.
- Excellence and efficiency of engineering and technical teams. Deadlines and targets were met and community time was not wasted. Also trust between the contractors and the householders was at a high level because of this efficiency.
- Use of participatory methodologies which were newly introduced to the field workers and the communities. There is need to provide participatory skills training and guided practice experience to communities, extension workers and NGO managers in Rwanda because such skills are not as widespread in as in other developing countries. Such skills can make a contribution to community cohesion and governance beyond natural resources management.
- The combination of granting of rain water harvesting technologies simultaneously with the community planning processes. This meant that a large proportion of householders could see immediate results from the rainwater harvesting technologies while being requested to participate in the wider and slower community process of analysing water resources and planning for their management. There is a fund established by the community members in each of 9 villages for the maintenance and repair of the technologies. Additionally, each village has finalised their action plan toward the climate change adaptation and they have begun the implementation of some activities with only minimal external support.
- All players, especially villagers, were interested and committed to participating – no sitting allowances involved!
- Close collaboration with government at village, cell, sector and district levels. Fully transparent collaboration with government is obligatory for NGOs in Rwanda. Done well it leads to government support to and adoption of project innovations. It thus can lead to action above the village level and to elevation of innovation to higher levels, even the national level.

2. Non-confrontational presentation of facts, such as villagers making public presentations of water resources issues through maps and the individual village vulnerability matrices, is an effective advocacy tool in Rwanda. It gives communities a framework

for expressing the specific bio-physical and socio-economic risks and threats which they are facing in their particular environments.

3. Women gain confidence when given their own space for expression and are then ready to take up leadership and representation roles. Of the 84 committee members, there are more women (47) than men (37) and the women are active and vocal in meetings in the villages and elsewhere.
4. Better management of water from homes and yards reduces conflict with downslope neighbours. Before the project interventions for rainwater capture there were cases of conflict with downslope neighbours because the runoff from upslope compounds was eroding their land. Once the rainwater harvesting systems were installed the erosion stopped and the conflicts were resolved.
5. Reasonably cheap rainwater harvesting solutions are available and some technical expertise exists in Rwanda, however, they are not widely disseminated.
6. Semi-underground tanks can be made more accessible, safer and more hygienic by installing simple hand pumps. No pumps were being provided for semi-underground tanks in the northern areas of Rwanda from which this project sourced the construction expertise. Therefore a very simple suction pump (EMAS pump) for each tank was constructed the first time on site with simple and available material at local level. This is a new innovation for semi-underground tanks in Rwanda.
7. The greatest problem in all nine communities is soil erosion within the farm fields resulting in production losses, gully formation, land slippage and siltation of wetlands. Although this pilot project has identified the problem, further experimentation with solutions to this problem is needed.
8. There is very high value in engaging communities in water resources analysis and planning. This value supports community cohesion, agricultural production and overall environmental resilience.

3.3.Encountered challenges and proposed solutions

1. Following the findings from the monitoring conducted during the last dry season, the capacity of the constructed water tanks (5,000 Litres to 6,000 Litres) is too small to bring the family through the dry season. As the rain is enough to fill more than 6,000 Litres, Trócaire jointly with partners and SCIAF have decided to increase the volume of tanks up to 8,000 Litres for bamboo tanks and to 10,000 Litres for semi-underground tanks. Greater attention also needs to be given to soil moisture retention measures.

2. The householders are not measuring their water usage and although the government advice against it, the harvested water is being used for drinking purposes. It is important to set in place simple systems of recording the harvest of water and the use of water so that the householder can decide on the priorities and decide on how to manage the available water.
3. The rainwater harvested is not considered potable but looks cleaner than some of the river water being consumed towards the end of the dry season. Trócaire didn't test the rainwater but plans to take samples from several tanks and have them tested in laboratories. Trócaire is also looking forward to find suitable ways for the householders to ensure that this water is cleaned before use. Sterilisation fluid (chlorine base) has been distributed in the past but it doesn't kill all germs. Tulip filters are now being tested for suitability.
4. Initially, the project used hard plastic sheeting for both the ponds and semi underground tanks. It has been noticed that the hard plastic sheeting is appropriate for the ponds and not for the semi underground tanks. In this regard, flexible sheeting have been adopted for the semi underground tanks to minimise the damages.
5. Technical construction errors need to be rectified and avoided in the future by better training and supervision for those constructing the installations
6. The extent of climate change impact in the project areas is not well known; apart from localisation of global data and from regional level meteorological data, there is very little information about the actual weather in the project areas. Regular recording of rainfall and water levels should be done in each village to help build up a picture of the weather and water relationships.

4. Conclusion

The pilot project has been very successful and there is huge demand by villagers, local and higher government to replicate the Community IWRM processes and the RWH technologies. In order to do this, further investment is needed in training for both the community watershed catchment planning processes and the RWH technology installation and maintenance in an integrated way. The government of Rwanda has identified the Integrated Water Resources Management as an important strategy for the country. However, national and district levels should involve Village level committees more in water resources management. This can be done by and better clarifying their roles for water and natural resources management, by strengthening their mandate and by providing training. The government should also commit to finding means to provide these supports to these nationwide village committees by including them formally under the legal and funding instruments at their disposal. Credit institutions should consider provision of credit for RWH installations and the government and donors should consider such interventions for grants under their Climate Change Adaptation strategies and budgets. Technological interventions should provide budgets and time for experimentation to find technologies which best suit users especially women and girls.

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Annexes

1. Checklist used in data collection for water harvesting systems installation

I. IDENTIFICATION		**Observations**
I.1. Household name	-	
I.3. Village (Umudugudu) and Cell	-	
I.4. Sector and District	-	
II. QUESTIONS		**Observations**
II.1. What is the site occupancy (people) in terms of number family member	- -	
II.4. In which condition are the existing rainwater harvesting facilities	a)poor b)good	
II.5. For which purpose harvested rainwater will be used?	a) Cleaning-- b) Washing-- c) Drinking-- d) Cooking-- e) Latrines-- f) Livestock g) Other--	
II.7. Indicate the direct negative impacts of rainwater runoff to your surrounding	-existing of erosion, gullies, flood, etc.	
II.8. Indicate the type of roof in terms of materials	a) Iron sheets b) Tiles c) Asbestos d) Others	

II.9. Presence of gutters	a) Available b) None	
II.10. Is the site access road in good conditions	a) Yes b) No	
II.12. What will be your contribution to the project implementation?	- -	

2. Pictures

Picture 2.1: *Bamboo tank construction process*

Picture 2.2: *Semi underground tank construction process*

Picture 2.3: Runoff *water pond construction process*