In-field water harvesting using contour bund with earth to cope with changing climate in semi-arid smallholder farming areas in Mali

Background and Justification

Most of the population in the Sahel is small-scale resource-poor farmers who rely mainly on rain-fed agriculture for their livelihoods. However, rainfall in this region is erratic, poorly distributed and very variable, which makes rain-fed agriculture a risky enterprise. Declining water quantity, increasing soil degradation and inappropriate crop management methods limit agricultural productivity, making food security a major concern in the smallholder farming sector. The most vulnerable people are the resource poor farmers, the elderly, women, children, and women and women-headed households because they have limited adaptive capacity.

Climate change models have projected a decrease in rainfall in the Sahel region, and research has already shown the same trends (CILSS). Decreasing rainfall implies worsening food shortages if the current farming practices do not improve. Hence focus should be on upgrading rain-fed smallholder farming characterized by frequent droughts and mid-season dry spells. In addition, most of the rainfall received is lost as runoff, and very little water is harvested for plant growth or future use. High levels of runoff losses in smallholder farming areas do not only limit water availability, but are also an erosion hazard and cause nutrient losses.

Improving water productivity requires that more value be obtained from every drop used for crops, trees and livestock while conserving the natural resource base. It is becoming increasingly clear that to face the food challenge over the coming years, combined efforts of developing climate smart rainfed agriculture will be required (Rockström 2002). To reduce the vulnerability to smallholder farmers in semi-arid regions to climate change and variability, and to increase the resilience to climate change there is need to optimize in-field water harvesting techniques so as to improve crop yields. It is therefore imperative to investigate the options to increase water productivity in rain-fed agriculture for increased food production. With improved in-field water harvesting, harvested rainfall can possibly sustain crop production during the mid-season dry spells and this will reduce crop failures and may ultimately lead to improved household food security.

The effects of soil bunds on runoff, losses of soil and nutrients, and crop yield are rarely documented. A participatory field experiment was set up consisting of three treatments: (i) crop-cultivated land without soil bund (Sb); (ii) crop-cultivated land protected with earth bunds (F); and (iii) (ii) crop-cultivated land protected with vegetated contour bunds with earth during the cropping season of 2017-2018. The effect of soil bunds on runoff, losses of soil and nutrients was investigated using farmer perception, and crop productivity was measured.

Planned comparison of earth bunds

The aim of this planned comparison is to find an alternative to stone bunds to reduce runoff and erosion while improving soil water infiltration and the productivity of crops. The factors to be considered in this trial are listed in table 1 and the trial will be conducted in 4 villages (Sakou, Bogonam Mossi, Bogonam fulbé, and Loaga) of the Northern Burkina Faso. Each participating farmer will be considered as a replicate and will compare at least two options: stone bund and one variant of earth bund. Those who can accommodate more than two options will be encouraged to do so. Participating farmers have already been identified during the DryDev CAP process but new volunteers will be accepted. Potential candidate species to be used to plant the earth bunds include: *Acacia colei* and *Andropogon gayanus*. This can be broadened if the need is expressed by the farmers. In priority, these three species are the ones to be tested and their seedlings will be produced in local nurseries to reduce the cost transportation and its shock on their survival of the seedlings. The inputs (seeds, containers, etc.) will be provided by the project, the farmers will contribute with labor in raising the seedlings and if needed, the NARS team will provide training on nursery and tree planting techniques. To give enough chance to the survival of the seedlings, they should be produced long in advance the planting period and as close as possible to the planting area.

Plan comparison design

This PC is going to compare the proven water control technology of stone bunds with its potential alternative earth bunds in various contexts using participatory action research. Each farmer will compare side by side earth bund of various modalities (planted or not with one of the three above mentioned species). This will require both a community-based approach with identified volunteers during the CAP and a landscape approach due to the potential side effects of controlling water in a plot to the neighboring one. Indeed, controlling water in one plot can cause damages in the plot next to it. Such potential hazards should be anticipated and dealt with at the community level (social capital). The treatments will comprise a control without bund, earth bunds and planted earth bunds.

Table 1: Detailed design summary

Question or objectives	Identify an alternative to the use of stones for bunds construction
Hypothesis	Planted earth bunds efficiency will vary according to factors like: land use types, soil types, farm types, slope, tree cover, woody species planted, farmer's social status, household size.
Options to compare	Control with no bunds (i) crop-cultivated land without soil bund (ii) crop-cultivated land protected with earth bunds (F) (iii) crop-cultivated land protected with vegetated contour bunds with earth (earth bund planted using Acacia colei only or and *Acacia colei* + perennial grass *Andropogon gayanus*
Contexts to compare	- Land use types - Soil types - Farm types (compound field, village field and bush field) - Slope - Tree cover - Social status (wealth class, ethnic group, autochthone / migrant, etc.), - Household size (labor)
Study units	Farm (minimum of one quarter of a hectare). Where space allows, farmers will try different alternatives side by side
Responses to measure	1. Measurable by farmers - Qualitative appreciation of the effort/time of maintenance

	- Qualitative appreciation of the efficiency (erosion reduction/moisture increase) - Cost benefit ratio (qualitative appreciation of farmers' effort and value: 'participatory cost-benefit analysis) 2. If student available Soil water content Grain and biomass yields Cost-benefit
Roles of farmers	- Provide the farm fields (enough space for trial) - Construct water conservation infrastructures - Ensure technical itinerary of production (sowing date and mode, weeding etc.) - Facilitate data collect
Roles of others	- Local partners (AMEDD, AMEPPE): training, oversight, monitoring and data collection - Agricultural extension office : training, oversight for the quality of water conservation infrastructures and implementation of the technical itineraries - ICRAF: Designing the protocol, monitoring and data collection (soil humidity, grain and biomass, cost), data analysis, reporting - Technician: Monitor grain and biomass yield as well as costs for cost-benefit analysis
Study/experimental design	Selection of the sites by the farmers Number of sites: 15 villages all located in the same sub-catchment Each farm = a replicate Comparing: Control, earth bunds and planted earth bunds For farmers: See part 1 of Responses to measure For technician: Establishing measurement plot for grain and biomass yields,
Suggested timing (start and end)	Start May 2017 – End December 2017
Data collection sheets	Annex the data collection sheets

Photo: A vegetated contour bund with Acacia colei

Photo: Crop yield measurement on a millet field

Study approach

A total of 318 farmers was considered. Each farmer is considered as replicate with at least the following the treatments on his plot: field without bund, earth bund planted or not. More treatments can be tested if feasible and according to the will of each volunteer farmer. The number participants per village depended on the number farmers who volunteer to take part in it. This number seems to be limited but it is reasonable because of the labor involved in building these structures in one hand and the resource for monitoring.

The establishment of the trials will be the responsibility of the DryDev national team with the support of national research system and ICRAF. DryDev team will organize farmers, gather the inputs required and set the timing for the establishment and ensure effective set up of these trials. The following steps were followed:

1. Community meetings were held in the sites to present the potential options to be tested. Each volunteer will then choose options and species he/she wants to try out in his/her field;
2. Visit the fields to lay out the design by determining the contour lines where the water conservation structures will be built.
3. Acquire the inputs and establish the nursery to raise the seedlings;
4. Construct the bunds and plant the seedlings at the onset of the rainy season.
5. Each volunteer to maintain and monitor the trial with technical support each time required. Monitoring involves farmers, lead farmers (those who can write), agricultural technician of the area and ICRAF teams at various levels.
6. Data analysis and lessons sharing. The same actors listed contributed in examining the data and pulling out the key messages to be shared as well as organizing the knowledge sharing events jointly with the project national team.

Monitoring and data collection

The 318 farmers were profiled using ODK. Data is both qualitative and quantitative. Information on soil and land use types, farm type, slope, tree cover, social status of the farmer, household size was collected for each participating farmer and constituted the context factors. Yield data was collected using data collection sheet.

Data management and analysis

Data was keyed in using an excel sheet and later cleaned before analysis. Yield data was used to calculate yield difference between the tested practice (variants of earth bunds) and its reference control. The difference and other parameters collected were analyzed using descriptive statistics.

Data Sheets

A. Farmer data sheet

Farmer ID: ________________

Location/ watershed: _______________________

Village: ________________________

Farmer's name: ____________________

Gender of HHH: ______________

Social status: ________________

HH size: Number of people____________ and number of active people_______________

Filed type (household, village or bush field): ____

Field size (ha):_____________

GPS coordinates: ___________________

Distance from farm to main road (km): ______________

Distance from farm to nearest main market (km):__________________

Soil texture (also indicate if varying within the farm): _______________________

Time since the land was opened to cultivation: _____________________________

Time since the land was fallowed: _____________________________

Crops commonly planted: ______________________________________

Is crop rotation done? Which is the most common rotation?: _________________________

Is fertilization usually done? Which fertilizer?: _______________________________

Does the farmer burn trash/ crop residue?: ________________________

Slope (degrees): _______________________________

Visible erosion (gully, sheet, rill):___________________________

Has the farmer ever employed a Soil Water Conservation practice before?: __________________

Which one?: ____________________________

Crop planted (include variety - local or improved):_____________________________

Distance from plot to homestead (m): ______________________________________

Farmer opinion on the field soil quality (Good/fair/poor): _________________

Indicators used (e.g. color, indicator plants etc.): ______________________________

Number of people for stone bunds construction: ______________________

Number of people for earth bunds construction: ______________________

Time spent in maintenance of stone bunds (h/d): ______________________

Time spent earth bunds (h/d):______________________

Advantage stone bunds on erosion control and crop yield: ______________________

Advantage earth bunds on erosion control and crop yield: ______________________

B. Data sheets collection for technicians or students
B1. General data sheet

Farmer ID: ________________

Location/ watershed: _______________________

Village: ________________________

Farmer's name: ____________________

Gender of HHH: ______________

Social status: ________________

HH size: Number of people____________ and number of active people_______________

Filed type (household, village or bush field): ____

Field size (ha):_____________

GPS coordinates: ___________________

Distance from farm to main road (km): ______________

Distance from farm to nearest main market (km):__________________

Soil texture (also indicate if varying within the farm): _______________________

Time since the land was opened to cultivation: _____________________________

Time since the land was fallowed: _____________________________

Crops commonly planted: ______________________________________

Is crop rotation done? Which is the most common rotation?: _________________________

Is fertilization usually done? Which fertilizer?: _______________________________

Does the farmer burn trash/ crop residue?: ________________________

Slope (degrees): _______________________________

Visible erosion (gully, sheet, rill):___________________________

Has the farmer ever employed a Soil Water Conservation practice before?: __________________

Which one?: ____________________________

Crop planted (include variety - local or improved):_____________________________

Distance from plot to homestead (m): ______________________________________

Farmer opinion on the field soil quality (Good/fair/poor): _________________

Indicators used (e.g. color, indicator plants etc.): ______________________________

Number of people for stone bunds construction: ______________________

Number of people for earth bunds construction: ______________________

Time spent in maintenance of stone bunds (h/d): ______________________

Time spent earth bunds (h/d):______________________

B2. Grain yield
Date: **Name data collector:**
Country: **Village**:

Farm	Bund treatment	Plot	Total weight for the plot	Weight 30 heads	Grain weight of 30 heads	Weight of 1,000 grains	Quality*

NB: *qualitative scoring for the sustainability of the water conservation structure with 1= excellent, 2 = good, 3 = poor and 4 = very poor or other local pastoralists' scale

B3. Straw yield
Date: **Name data collector:**
Country: **Village**:

Farm	Bund treatment	Plot	Total weight for the plot	Fresh weight sub-sample of straw	Dry weight sub-sample of straw

NB: *qualitative scoring with 1= excellent, 2 = good, 3 = poor and 4 = very poor or other local pastoralists' scale

B4. Soil water

Date: **Name data collector:**

Country: **Village**:

Farm	Bund treatment	Plot	Sampling point	Fresh weight	Dry weight

NB: Water content = Fresh weight – Dry weight using gravimetric method

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