MEMORANDUM OF UNDERSTANDING (MOU)

BETWEEN

THE CLIMATE CHANGE ADAPTATION AND AGRIBUSINESS SUPPORT PROGRAMME (CASP) OF THE FEDERAL MINISTRY OF AGRICULTURE AND RURAL DEVELOPMENT OF NIGERIA (FMARD)

AND

INTERNATIONAL CENTER FOR AGRICULTURAL RESEARCH IN THE DRY AREAS (ICARDA)

FOR CONDUCTING

SUSTAINABLE LAND MANAGEMENT ACTIVITIES

IN CASP AREAS OF THE SAVANNAH BELT OF NORTHERN NIGERIA

TOWARDS IDENTIFYING CONTEXT-SPECIFIC SOIL AND WATER CONSERVATION PRACTICES AND WATER HARVESTING SYSTEMS FOR THE SAVANNAH BELT OF NORTHERN NIGERIA: A MATRIX OF OPTIONS

TECHNICAL REPORT

2018

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List of Acronyms

CAP	: Community Action Plan
CCS	: Climate Change Specialist
CDA	: Community Development Area
ET	: Effectiveness Table
FYM	: Farm Yard Manure
ICARDA	: International Center for Agricultural Research in Dry Areas
IFAD-CASP	: International Fund for Agricultural Development – Climate Change Adaptation and agribusiness Support Programme
IFAD-CBARDP	: International Fund for Agricultural Development – Community-Based Agricultural and Rural Development Programme
LGSO	: Local Government Support Office
MO	: Matrix of Options
NPC	: National Programme Coordinator
NPK	: Nitrogen (N) Phosphorus (P) Potassium (K)
PLUP	: Participatory Land Use Planning
SLM	: Sustainable Land Management
SSO	: State Support Office
SSP	: Single Super Phosphate
SWC	: Soil and Water Conservation
VA	: Village Area
WH	: Water Harvesting
WOCAT	: World Overview of Conservation Approaches and Technologies

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1. Introduction and background

There are hundreds of technical techniques for improving the sustainability of land management and preventing or reversing degradation, but there are many technical, socio-cultural, institutional, economic and policy barriers hindering their adoption at large scale (Thomas et al., 2018)[1]. A basic but major issue is the great variability of the concerned socio-ecological contexts: technologies need to be screened and adapted to these contexts, piloted and disseminated. Along this process, the "adoptability" of these technical options needs to be evaluated by the communities, and the barriers to adoption identified and where possible removed.

In the savannah belt of Northern Nigeria, ICARDA is supporting the CASP Programme (Climate Change Adaptation and Agribusiness Support of the Federal Ministry of Agriculture and Rural Development of Nigeria) in identifying and implementing location-specific, effective and innovative soil and water conservation (SWC) and water harvesting (WH) adaptation techniques. The final goal is mainstreaming climate change adaptation measures, through a landscape rehabilitation approach focused on sustainable land management.

As part of this collaborative work, ICARDA has developed a community-based participatory approach to screen and identify sets of potential SWC/WH options matching the community needs, and to bring them to the communities for their consideration, discussion, and possible adoption, in the frame of the broader participatory planning process established by CASP.

This report summarizes the results of the screening and identification phase, which ended-up with the formulation of "matrix of options" for each of the targeted communities, as illustrated in the next sections. The identification process was based on the results of a previous diagnostic survey of the current adoption of SWC/WH practices by farmers in the CASP sites, particularly on the assessment of the effectiveness of these practices.

The diagnostic survey was implemented in April-May 2018, based on a methodological protocol purposely developed by ICARDA[2], on a representative sample of communities engaged in the CASP Programme (Figure 1). The visited sites were selected as representative of different bio-physical and socio-economic conditions, and affected by a range of land degradation problems

[1] Thomas RJ, Reed M, Clifton K, Appadurai AN, Mills AJ, Zucca C., Kodsi E, Sircely J, Haddad F., von Hagen C, Mapedza E, Wolderegay K, Shalander K, Bellon M, Le QB, Mabikke S, Alexander S, Leu S, Schlingloff S, Lala-Pritchard T, Mares V, Quiroz R, 2018. A framework for scaling sustainable land management options. Land Degradation and Development. DOI: 10.1002/ldr.3080.

[2] Diwediga B., Zucca C., 2018. "Participatory Survey on Soil and Water Conservation Practices and Water Harvesting Systems in the Savannah Belt of Northern Nigeria". Technical Report. International Center for Agricultural Research in Dry Areas (ICARDA). Rabat, Morocco.

(particularly water erosion) and land management issues. Schematically, the protocol includes 6 steps organized in 2 phases, with group interviews and individual interviews, as follows:

Phase 1: Group interview with community members, to i) introduce the main, most frequent crops and farming systems around the village, ii) discuss SWC issues and related actions as identified by the communities, and iii) Identify farmers ("adopters" of SWC/WH practices, or "non-adopters") for individual interview at fields.

Phase 2: Farm visit with selected farmers, individual interview, and direct field observations, to document i) soil and water degradation processes, soil type, and water availability, ii) farming practices, iii) specific SWC/WH practices, and iv) geo-reference the observations.

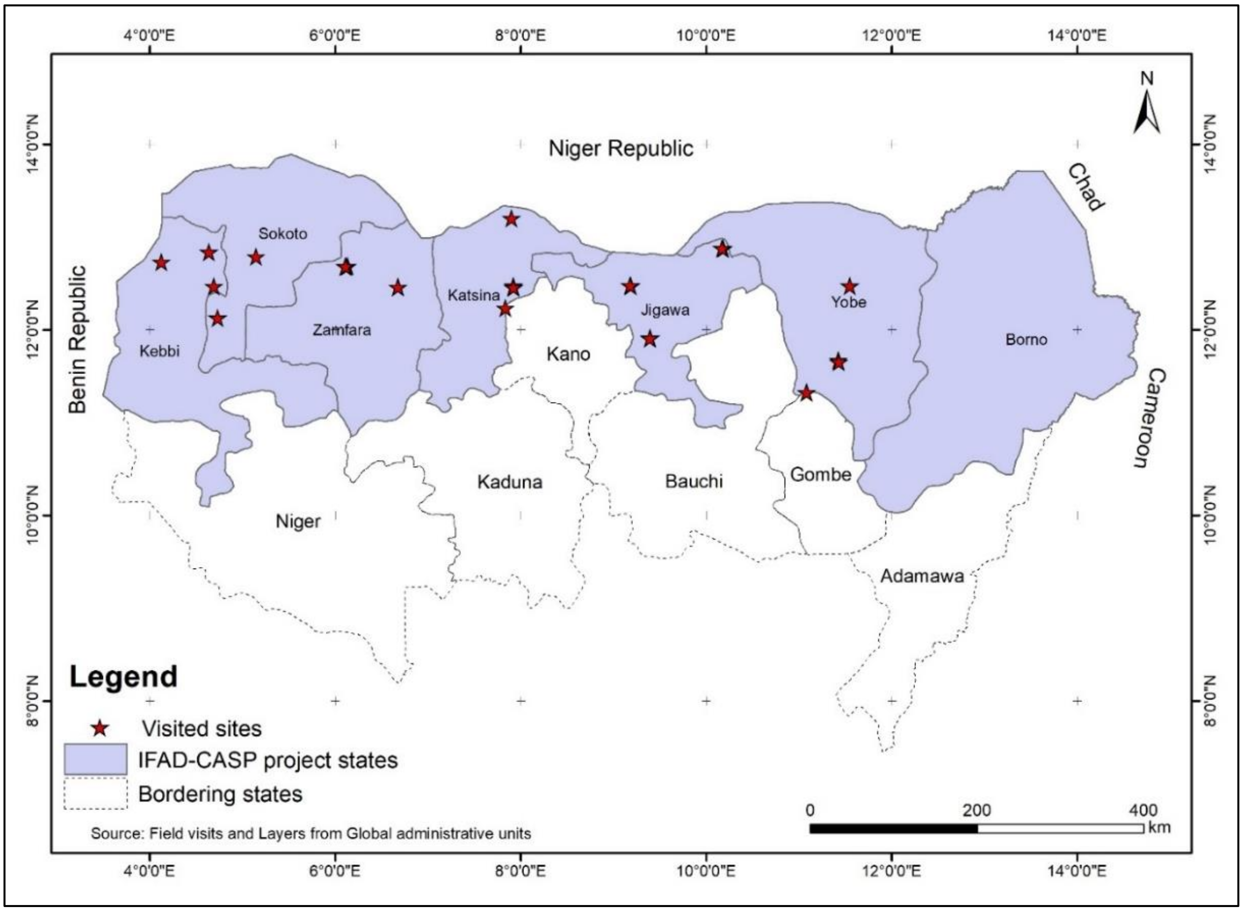

Fig 1. Visited Community Development / Village Areas (CDA/VA) in IFAD-CASP States (Source: Author development, May 2018)

2. Methodology

A draft matrix of recommended community-specific options (MO) has been drafted for each of the surveyed communities based on the survey results, and on a literature review, and on additional participatory sessions conducted at community level during summer 2018.

The MO is a suite of SWC/WH techniques that fit with the specific context as documented at sites, mainly including soil erosion control measures, water harvesting systems, and soil fertility management practices. The proposed options mainly target the rainfed production systems (rainfed cereals and associated cash crops, with livestock integration). Some practices are intended to be alternative to each other, other complementary (e.g. biological fencing as windbreak in association with improved cropping at fields).

The following steps were followed to draft the MOs:

1. Compile the techniques currently practiced, based on the survey results, and identify needs for improvement/integration of the current practices (e.g., in a given community earth bunds are in use but they are not well implemented and their pattern in the landscape not appropriate; in another community manure is too scarce due to poor livestock integration, etc.);
2. Identify “cross-fertilization” potential by evaluating the possibility to transfer know how from similar/neighboring communities, or, in other terms, to introduce techniques already applied locally;
3. Identify, based on international literature, further feasible options that are in use in the same agro-ecological and socio-economic contexts, in Nigeria or elsewhere, and that could be reasonably adopted (“broader, or international fertilization”).
4. Conduct a second run of participatory community meetings to discuss the draft matrix and to collect further feed-back on the recommended improvements, as well as on the ongoing practices that may have been missed during the initial survey.

After the fourth step it was possible to draft the final version of the MOs as shown in this report. The latter participatory work is not described here, but will be the subject of another, specific report.

The MOs have two dimensions, the “Option” (or technology package) dimension, and the “Issue” dimension. On the “option” dimension the MO has 4 entries:

- Currently practiced

- Currently practiced, advised improvement
- Advised local import
- Advised international import

On the “issue” dimension, the MO has as many entries as the problems dealt with are. The evaluation is to be conducted for each SWC and WH issue, separately. As an example, a given community may have two major SWC issues to cope with, such as “wind erosion” and “soil infertility”, and one WH issue, such as “Water shortage for animal drinking”. In this case the MO will have 3 entries on the issue dimension.

As mentioned in section 1, the MO content is based on the analysis of the effectiveness of the measures currently practiced by the communities. The schematic results of this analysis (effectiveness tables - ET) are presented in the next section (section 3). Here, the effectiveness is evaluated from both the farmer and the expert perspectives. The information given in the tables refer to the targeted communities and to the sample of the farms that we surveyed and is meant to provide indications about the actions most likely required at the community level.

In section 4, the MOs are presented for the target communities. The MOs illustrate the practices currently adopted, summarize the recommended improvements, suggest the possible uptake of practices adopted in other CASP communities under comparable conditions (“cross-site” fertilization), and identify further practices (“international” fertilization) in use in other countries and regions, which may fit the local conditions. The MO must be interpreted on the basis of the analysis proposed by the ET tables.

Section 5 summarizes some important constraints, challenges and factors of SLM adoption observed in the CASP area.

Finally, in section 6, some multi-scale (holistic interventions) are suggested for addressing the key land degradation issues at field, community and landscape levels.

The MO drafting process was reinforced by interactive training and discussion sessions held with the participation of the ICARDA and the CASP project teams. During this event organized by ICARDA in Amman (Jordan) in June 2018, ICARDA scientists summarized the data gathered through the diagnostic phase, illustrated the proposed methodological approach to identify candidate options for the MOs, and animated discussion sessions to collect feed-back and to launch the drafting process.

3. Effectiveness of current SWC/WH techniques and recommended improvements

3.1. Effectiveness of conservation practices in the communities in Jigawa State

Table 1. Effectiveness of SWC practices as observed in the surveyed sites in Jigawa State

CDA / VA	Adopted measures	Weakness points (farmer perception)	Technical issues (expert evaluation)	Recommended improvement
Kukawa	Crop residue on-site	Insufficient quantity of residues for both animal feeding and soil restoration	-Illegal grazing reduces the quantity of residues on site -Residues on site are not fully reintegrated to the soil (no full decay and mineralization)	-The residues can be more efficiently used through composting on farm. -Planting leguminous trees/shrubs can be an effective solution to improve vegetation cover on the field, increase soil fertility and control wind erosion
	Late land preparation	Huge work load at planting time	For gaining time due to late preparation, farmers often burn the organic matter reducing nutrient recycling	Proceed to land preparation on time and leave the cleared grasses and shrubs on the ground to serve as mulching.
Kukawa, Dagwaje	Planting holes	Labor demanding and time-consuming Practiced on annual basis	The technology does not reverse wind erosion and deposition because wind velocity is fed from surrounding bare lands	Provide living structure in rows crossing the farm) or fences (at farm edge) to abate wind velocity and reduce sediment deposition
Kaya	Stone bunds	Capital and labor demanding (costs of inputs for establishment and maintenance)	Stone bunds are not well constructed (i.e. size of bunds, the size of the stones and their placement are not appropriate)	- Increase the height and tightness of the stone bunds - Replicate the number of stone lines to abate the flow velocity - Always associate a vegetative component (planting shrubs or grasses) to support the structures
	Sand bags	No case was observed	No case was observed	- Use bags of good resistance to avoid the destruction (induces pollution) and do replace them on yearly basis. - Dispose the sand bags across the slope/gully to abate flow and stop sediment to replenish the soil level - Undertake collective efforts with neighbor farmers to address erosion at gully initiation point

	Planting grasses & shrub fencing	Not effective as the structure is not addressing the issue Very costly and time-demanding	- Not effective, gully and runoff not addressed at their source - Single case in a catchment cannot abate the runoff velocity - the vegetative component is quite not existent - the structure is affected by rural tracks - No technical support (the technology is traditional)	- Replace the dry shrubs by living ones - Plant regular rows of shrubs that can resist to runoff - Address erosion issue at gully initiation point
Kaya, Dagwaje	Manuring	Not enough quantity of manure	-Mixture of any kind of wastes (e.g. plastic bags) inducing pollution -No efficiency as if the manure was composted	- Proceed to manure management and composting at farm for more efficiency - Avoid the mixture of domestic wastes such as plastics to reduce soil pollution
Dagwaje	Fallowing	Reduction of land size for cultivation (only 20% of farmers can afford)	-Wild fallows affected by animal transits and grazing -No assistance for quick land recovery	- Plant cover crops (e.g. Mucuna or similar leguminous) on plots set to fallow - Minimize the risks of illegal grazing using fencing
Dagwaje, Kukawa	Mulching	Illegal grazing on the mulched fields	Illegal grazing reduce the optimal benefits from the practice	Control grazing, or switch to composting on farm

Table 2. Effectiveness of WH systems as observed in the surveyed sites in Jigawa State

CDA / VA	**Adopted measures**	**Weakness points (farmer perception)**	**Technical issues (expert evaluation)**	**Recommended improvement**
Dagwaje, Kukawa	Ponds	Not sufficient to the community (not addressing water shortage issue) No care for maintaining the ponds	-Small size and not suited to store water during dry season -No maintenance by communities (issue of common good) -Not established on suitable sites (ponds are usually the results of borrow pits) -Structures are not really constructed for the purpose of water harvesting and storage -No defined maintenance plan	- Enlarge and transform ponds to store water year-round -Establish ponds/dams on suitable sites (cross streams, gullies/runoff ways, lowlands) to increase water harvesting potential -Plant trees and grasses around dams/ponds to reduce insolation and evaporation - Possibly avoid free livestock access and trampling from all directions
Kukawa	Solar-powered water pipes	Water is not enough for all the community	Maintenance failure	Provide equipment that can be sustainably maintained by the communities

3.2. Effectiveness of conservation practices in the communities of Katsina State

Table 3. Effectiveness of SWC practices as observed in the surveyed sites in Katsina State

CDA / VA	Adopted measures	Weakness points (farmer perception)	Technical issues (expert evaluation)	Recommended improvement
Baawa	Vetiver grass planting on farm edge to control gullies	-Reduce land availability -Compete with crops for nutrients -Planted grasses are often washed away	-The grasses are scattered -The rows of grasses are not long enough -The measure is not addressing the runoff at its initiation point	-Increase the grass density and the length of the planted rows in association with earth/stone bunds -Adopt contour ploughing
	Sand bags	-Reduce drainage, can locally induce waterlogging -Reduce farm size -Labor demanding	-Land is ploughed along the slope -Sheet erosion still occurs	-Develop long term measures (e.g. diversion channel sustained with vegetative measures) that address the runoff at its initiation points -Build check dams -Use bags of good resistance to avoid the destruction (also inducing pollution) and replace them on yearly basis. -Dispose the sand bags across the slope/gully to abate flow and stop sediment to replenish the soil level -Collectively with neighbor farmers, address erosion issue at gully initiation point -Control runoff formation/concentration upstream
	Manuring	-Input cost, on yearly basis -Insufficient quantity of manure	-Mixture of any kind of wastes (e.g. plastic bags) inducing pollution -No efficiency since part of the manure is carried away by runoff and nutrients are used by weeds	Proceed to manure management and composting at farm for more efficiency
	Mulching	Not enough crop residue for both animal feed and mulching	Not effective due to illegal grazing	-Proceed to composting at farm for more efficiency and reduce uptake by illegal grazing -Planting cover crops (such as Mucuna or similar leguminous)
Garu	Vetiver grass planting	Same as Baawa	Same as Baawa	Same as Baawa
	Sand bags	Same as Baawa	Same as Baawa	-Build check dams

				-Use bags of good resistance to avoid the destruction (also inducing pollution) and replace them on yearly basis -Dispose the sand bags across the slope/gully to abate flow and stop sediment to replenish the soil level -Collectively with neighbor farmers, address erosion issue at gully initiation point -Control runoff formation/concentration upstream
	Combination of sand bagging, stone bunds, and ridge ploughing	-Requirement of labor and time for implementation -Annual maintenance is required (time and cost)	-Ridging is not done along the contour lines exposing the plot to more erosion -The combination of measure is not appropriate to address the erosion, given its severity and extent	-Adopt contour ploughing -Develop long term measures (e.g. diversion channel sustained with vegetative measure) that address the runoff at its initiation point
	Plant cover species (*Datura arborea*) & Ron palm (*B. aethiopum*)	No case	Low density of planted species in erratic patterns does not help to control the erosion	Plant with good density of species on long rows in association with earth/stone bunds for more effectiveness
	Manuring	Same as Baawa	Same as Baawa	Same as Baawa
Kofa	Stone bunds	Capital and labor demanding (costs of inputs for establishment and maintenance)	Stone bunds are not well constructed (i.e. size of bunds, size of the stones and their placement are not appropriate)	-Address the gully erosion at the initiation point -Increase the height and tightness of the stone bunds and replicate the number of stone lines to abate the flow velocity -Always associate a vegetative component (planting shrubs or grasses) to support the structures -Develop long term measures (e.g. diversion channel sustained with vegetative measure) that address the runoff at its initiation points
	Combination of sand bagging, stone bunds,	-Annual maintenance (capital and labor demanding)	-The ridge of sand bag and stone bunds are not long enough	Address the gully erosion at the initiation point develop long term measures (e.g. diversion channel sustained with vegetative measure) that address the runoff at its initiation points

	shrub planting and ridge ploughing	-Along a rural track; with alteration effect due to people and animal passing	-Not adequate measure to control gully at initiation point -No vegetative measure to supplement in the long run the structural measure (especially sand bags, decaying over time) Ploughing is along the slope (reportedly, to avoid waterlogging!)	
	Combination of stone bunds and sand bagging	Same as recommended for the two options above	Same as recommended for the two options above	Combine the recommendations as above, in appropriate manner
	Water diversion	/	/	-Associate vegetative measures (e.g. shrubs/trees planting) to sustain the structure -Adopt contour ploughing and integrate the measures
	Sand bags (for gully plugging)	Same as Baawa	Same as Baawa	Integrate the water diversion to the above measures targeting farm fields and gullies
	Manuring	Same as Baawa	Same as Baawa	Manure management and composting at farm for more efficiency Application in the planting holes/points to reduce losses

Table 4. Effectiveness of WH systems as observed in the surveyed sites in Katsina State

CDA / VA	**Adopted measures**	**Weakness points (farmer perception)**	**Technical issues (expert evaluation)**	**Recommended improvement**
Kofa, Baawa Garu	Ponds for animal drinking	-Early dry up -No management plan	-Small size ponds and not suited to store water during dry season -No maintenance by rural communities (issue of common good) -Not established on suitable sites (i.e. ponds are usually the results of borrow pits)	-Enlarge and transform ponds to store water year-round -Establish ponds/dams on suitable sites (cross streams, gullies/runoff ways, lowlands) to increase water harvesting potential -Plant trees and grasses around dams/ponds to reduce insolation and evaporation. Planted trees should be sustained by half-moons/micro catchments to ensure successful growth of seedlings

			-Structures are not really constructed for the purpose of water harvesting and storage -No defined maintenance plan	-Possibly avoid free livestock access and trampling from all directions
Kofa, Baawa Garu	Bore holes & Open wells for domestic use	Water is not enough for all the community	Maintenance failure	-Provide equipment that can be sustainably maintained by the communities -Use solar or wind energy to power bore-holes for multipurpose usages

3.3. Effectiveness of conservation practices in the communities in Kebbi State

Table 5. Effectiveness of SWC practices as observed in the surveyed sites in Kebbi State

CDA / VA	Adopted measures	Weakness points (farmer perception)	Technical issues (expert evaluation)	Recommended improvement
Barangawa	Contour bunds (embankments)	-Need annual maintenance -Animal effects on the structure during free grazing	-The size of the structure need improvements -The long term maintenance of the structure need a combination with vegetative measures	-Combine the contour ridging with earth bunds stabilized with grasses (Vetiver or Gamba or other locally available grasses) or shrubs (Jatropha) for more effectiveness -Control gully initiation points using vegetative measures (grass planting associated to soil bunds)
	Manuring	-Insufficient quantity of manure -Induction of weed spread	-Part of the manure is washed away by surface runoff/sheet erosion -Manure is not effectively incorporated to the soil and mineralized for crops	-Manure should be managed in composting for more efficiency -Adopt application of produced compost in planting holes/points to reduce losses (rather than broadcasting)
	Planting pits	Labor and time-consuming for establishment	-Need to be done on regular patterns (in lines) to optimize spacing -The pits are dug using traditional hoes (issues related to large scale implementation)	-Make sure the pits are not dug at the same places every year to ensure a kind of rotation -Adopting the half-moon/micro-catchment technique could offer more effectiveness and reduce labor inputs
	Planting Vetiver grasses	-Annual maintenance is needed as some seedlings are carried away or destroyed by animal -Competition for nutrients with crops -Reduction of available land size for cultivation	-Grasses are planted without any supporting structure (earth bund, etc.) -The patterns of the planted grasses are often not effective	-Improve the planting patterns (in lines across the slope) and density of grass spots, preferably along soil bunds -Consider the whole area under erosion as priority area for planting. -Preferably, integrate structural measures (soil/stone bunds) with shrubs (e.g. Jatropha) to plug the gullies -Control the gully initiation points using vegetative measures (grass planting associated to soil bunds)
Bui	Planting pits	Same as Barangawa	Same as Barangawa	Same as Barangawa
	Contour ridges/contour ploughing		-The land is ploughed without any conservative measure (bunds, vegetation lines, etc.)	-Combine the contour ridging with earth bunds stabilized with grasses (Vetiver or Gamba) or shrubs (Jatropha) for more effectiveness

			-The gully initiation point is not controlled causing severe gully formation downward -Sometimes, the ploughing is not really made along the contour, making the soil more prone to runoff/erosion	-Control gully initiation points using vegetative measures (grass planting associated to soil bunds)
Masama	Manuring	Insufficient quantity of manure	Same as Barangawa	Same as Barangawa
	Planting pits	Same as Barangawa and Bui	Same as Barangawa and Bui	Same as Barangawa and Bui
	Planting grasses (*Datura arborea*)	-/-	-/-	Same as suggested for Barangawa ("Planting Vetiver grasses")
	Sand bags	Input costs (due to the decay of the bags and annual maintenance)	-Sand bags are often misplaced, not covering the width of the gully nor protecting its whole length -Annual maintenance required (bags used are rapidly decayed due to poor quality)	-Placement of the sand bags of adequate size should be effective in plugging the gully (covering its width and depth) -Use bags of good quality (resistant materials) -Progressively restore the lands by associating vegetative measures (planting shrubs like Jatropha)
	Fallowing	-Lands are not enough for lengthy fallow -Encroachment by animals	Fallows are not well managed and protected (should be assisted and protected for quick regeneration)	-Adopt improved fallowing by enriching the fallow with planted leguminous trees or grasses -Protect the fallow against intensive grazing to ensure quick restoration
	Planting leguminous species (cowpea, groundnut)	-/-	The crop residues are not sufficiently well managed (often, they are collected for fodder)	Since crop residues are hardly left on ground because of animal feeding/grazing, compost making and application can contribute improving soil structure and fertility
	Contour ridges/contour ploughing	-/-	-The land is ploughed without any conservative measures (bunds, vegetation lines, etc.) -The gully initiation point is not controlled causing severe gully downward	-Combine the contour ridging with earth bunds stabilized with grasses (Vetiver or Gamba) or shrubs (Jatropha) for more effectiveness -Control gully initiation points using vegetative measures (grass planting associated to soil bunds)

Contour bunds	Large labor and capital demand for maintenance	-Portions of the bunds are nearly inexistent due to maintenance failure and animals -The bunds are not well stabilized along the whole length	-Undertake a general maintenance of the bunds (as width and height) -Re-establish the vegetative measures and expand the planting of trees/shrubs along the bunds -Undertake peer sensitization on the adoption of the techniques based on proven success of the demonstration trials

Table 6. Effectiveness of WH systems as observed in the surveyed sites in Kebbi State

CDA / VA	Adopted measures	Weakness points (farmer perception)	Technical issues (expert evaluation)	Recommended improvement
Bui	Half-moon	-/-	-/-	No improvement recommended
Masama	Half-moon	-/-	-/-	No improvement recommended
Masama, Bui	Ponds	- Early dry up - No management plan	-Small size ponds and not suited to store water during dry season -No maintenance by rural communities (issue of common goods) -Not established on suitable sites (i.e. ponds are usually the results of borrow pits) -Structures are not really constructed for the purpose of water harvesting and storage -No defined maintenance plan	-Rehabilitate the existing ponds (e.g. use of lateritic concretes (basal) to reduce infiltration) to store water year-round -Plant trees and grasses around dams/ponds to reduce insolation and evaporation Possibly avoid free livestock access and trampling from all directions

3.4. Effectiveness of conservation practices in the communities in Sokoto State

Table 7. Effectiveness of SWC practices as observed in the surveyed sites in Sokoto State

CDA / VA	Adopted measures	Weakness points (farmer perception)	Technical issues (expert evaluation)	Recommended improvement
Badau, Kebbe	Planting shrub species (*Datura arborea*)	Reduction of the cultivated field size	Patterns and density are not appropriate for effectiveness	-Need to improve planting patterns and density -Planting can be associated to structural measures plugging the gullies -Gully control at initiation point is recommended
	Contour ridges /Contour ploughing	-/-	-The ridging/ploughing is not correctly done along the contours -The contour ridging is not effective for gully control	-The ridging/ploughing should be effectively done following the contour lines -Integration of combined structural (soil bunds/stone bunds) and vegetative measures (Vetiver/Gamba) is encouraged
Badau	Sand bags	Costs of inputs (due to the decay of the bags and annual maintenance)	-Sand bags are often misplaced, not covering the width of the gully nor protecting its whole length -Bags used are rapidly decayed due to poor quality	-Placement of the sand bags should be effective in plugging the gully (covering its width and depth) -Use bags of good quality (resistant materials)
	Stone bunds	Capital and labor demanding (costs of inputs for establishment and maintenance)	-Stone bunds are not well constructed (i.e. the size of bunds, the size of the stones and their placement are not appropriate)	-Construct the stone bunds using appropriate materials (size of stones) -The size (height and width) of the bunds need to match the site conditions -There is possibility of integrating vegetative measures (planting shrubs/grasses)
	Combination of measures (*Hypomea sp.*, *Vetiver sp.*, earth bunds, stone lines)	Labor and time demanding for the maintenance inputs	-The combination of measures is not done in optimal manner (not really integrative and complementary) -The patterns of planted grasses / placement of stones, etc.) of the measures still need improvement	-Always combine structural (earth bund, stone bunds) and vegetative (grasses) measures for optimal effects and effectiveness -Improve the density of grasses and plant them along the bunds -The vegetative measures can be improved using locally available *Jatropha curcas*
	Crop residues on-site	Insufficient quantity of residues for both animal feeding and soil restoration	-Illegal grazing reduces the quantity of residues on site	-The residues can be more efficiently used through composting on farm -Trees/shrubs plantation can be an effective solution to wind erosion & deposition

			-The residues on site are not fully reintegrated to the soil (no full decay and mineralization)	
Kebbe	Planting Vetiver grass	-Reduction of cultivated field size -Competition for nutrients between the grasses and the crops -Illegal grazing affects the grasses	The patterns and density of the planted Vetiver are often not well done to avoid competition for nutrients with crops and cannot effectively control erosion	Improve planting patterns and density of grass spots, preferably along soil bunds
	Planting cover species (*Hypomea sp.*)	Reduction of cultivated field size	The patterns and density of the planted grasses are often not properly done throughout the erosion prone areas	-Plant the cover species over the areas under erosion. -Preferably, integrate structural measures (sand bags, soil/stone bunds) with shrubs (e.g. Jatropha) to plug the gullies and avoid reduction of land size
	Planting graminea grass (*Kakarkua in Haussa*)	-Reduction of cultivated field size -Competition for nutrients between grasses and crops	-This cover grass is not suitable for cultivated lands but recommended for abandoned lands and moving sands (stabilization of sand dunes).	-Use this grass for sand dune stabilization -Plant Vetiver/Gamba grasses in association with soil/earth bunds to control sheet erosion -Gully plugging sustained with shrubs (e.g. Jatropha) is advised -Gully control at its initiation point is recommended
	Agroforestry associated with earth bunds	-Labor and capital demanding for monitoring and maintenance -Illegal encroachment by animals	Small scale adoption observed (on less than 0.25 hectare)	-Scale up this good practice -Plant *Jatropha curcas* at farm hedge to protect the managed lands
	Manuring	Insufficient quantity of manure	-Part of the manure is washed away by surface runoff/sheet erosion -Manure is not effectively incorporated to the soil and mineralized for crops	-Manure management for composting for more efficiency -Adopt the application of compost in planting holes/points to reduce losses
	Fallowing	-Insufficient lands for long fallowing -Illegal grazing on fallowed lands	Fallowed lands are not assisted for recovery	-Improve the fallowing by planting leguminous trees or grasses -Appropriate crop rotation can be adopted

	Area closure	Reduction of land availability for cropping	Illegal encroachment of cattle and small ruminants reduces land restoration success	Construct wire fencing that can be progressively replaced by vegetative measures such as planting *Jatropha curcas*.

Table 8. Effectiveness of WH systems as observed in the surveyed sites in Sokoto State

CDA / VA	Adopted measures	Weakness points (farmer perception)	Technical issues (expert evaluation)	Recommended improvement
Kebbe Badau	Ponds/borrow pits (one under rehabilitation)	Water shortage occurs during dry season	-No management plan of ponds (issues of common pools) -Ponds are not well designed with appropriate size	- Rehabilitate/enlarge ponds to store water year-round - Improve the diversion channel towards the pond catchment under rehabilitation to increase water harvesting potential - Plant trees and grasses around dams/ponds to reduce insolation and evaporation - Possibly avoid free livestock access and trampling from all directions - Management plans for sustainable use of the ponds/water points
Water shortage for both livestock and domestic use	Bore holes (hand pumps, motorized) Open wells	Lack of energy systems to pump ground water	Some pumps are failed, no maintenance	Install pumping systems using sustainable sources of energy (solar, wind) to power bore-holes.

3.5. Effectiveness of conservation practices in the communities in Zamfara State

Table 9. Effectiveness of SWC practices as observed in the surveyed sites in Zamfara State

CDA/VA	Adopted measures	Weakness points (farmer perception)	Technical issues (expert evaluation)	Recommended improvement
Yautabaki	Planting cover species (*Hypomea sp.*) + ron palm	-Land size is reduced -Need annual maintenance as some of newly planted plants are carried away or destroyed by animal	-The ron palm are planted in a single row -The tree density is low making the living structure less effective -The planted ron palms are not addressing the gully at its initiation point	-Increase the density and the number of planted rows to effectively plug the gully -Address the gully at its initiation point by stabilizing the soil
	Fencing + planting cover grasses (*Hypomea sp. Datura arborea*)	-Annual maintenance is needed as some of newly planted plants are carried away or destroyed by animal -Not effective in addressing the gully formation and enlargement	-The fencing material is dead shrubs (not sustainable) -No effective measure to address the gully at its initiation point and along its whole length	-Provide a solid living structure by planting shrubs/trees at the gully bank to stabilize the gully -Associate gully plugging measures (stones, sand bags as check points) -Address the gully at its initiation point by stabilizing the soil
	Planting Vetiver grass	-Annual maintenance is needed as some of newly planted plants are carried away or destroyed by animal -Competition for nutrients with crops -Reduction of available land size for cultivation	-Grasses are planted without any supporting structure (earth bund, etc.) -The patterns of the planted grasses are often not effective	-Integrate the grass planting with earth bunds for more effectiveness -Improve the patterns of the planted grasses (in regular rows with acceptable density)
Goran	Contour ploughing	-/-	-Sometimes, the ploughing is made along the contour, but without ridging, making the soil loose and prone to runoff/erosion -Some measures are needed to address the gully/runoff at its generation point	-Adopt contour ridging associated with earth bunds consolidated by planted grass (Vetiver or Gamba) for more effectiveness -Address gully at its initiation point

Sand bags associated with stone bunds	Need annual maintenance inputs and labor	-The bags used are of poor quality, and are degraded in short time -The size and patterns of the structures are often not appropriate to control the gully and runoff -No vegetative measure is associated to the structure, making its unsustainable	-Sustain the practice using material of good quality -Integrate vegetative measures (shrubs/tree or grass planting) to sustain the structure -Increase the size of the structures and their number across the main gully and runoff flow direction
Cover crops	-/-	-The cover crops are not perennial -The cover crops can be washed away by the runoff, if the gully is not addressed at its initiation point	-Adopt grass planting associated with earth bunds -Adopt ridge ploughing across the runoff flow direction
Planting Gamba grasses (*Andropogon species*)	-Annual maintenance is needed as some of newly planted plants are carried away or destroyed by animal -Competition for nutrients with crops -Reduction of available land size for cultivation	-Grasses are planted without any supporting structure (earth bund, etc.) -The patterns of the planted grasses are often not effective	-Associate the grass planting with earth bunds -Address gully at its initiation point
Mulching associated with grass planting (*Hypomea sp.*)	Labor and capital demanding for maintenance of planted grasses and large scale adoption	-The mulching is not effective if there is animal grazing -The soil cover is very poor and could be improved by trees with agronomic benefits (soil stabilization, fertility improvement, etc.)	-Proceed to composting -Integrate indigenous leguminous species (agroforestry systems) into cultivated lands
Combination of manuring, mulching and ridge ploughing	-Insufficient amount of manure -Illegal animal grazing	-No efficiency since part of the manure is carried away by runoff and nutrients are used by weeds -Application of manure broadcasted, inducing losses	-Proceed to composting -Integrate indigenous leguminous species (agroforestry systems) into cultivated lands
Cultivation of adapted crops (paddy rice, vegetables)	-/-	-/-	No improvement recommended

Table 10. Effectiveness of WH systems as observed in the surveyed sites in Zamfara State

CDA/VA	Adopted Measures	Weakness points (farmer perception)	Technical issues (expert evaluation)	Recommended improvement
Yautabaki, Goran	Ponds	No water available year-round (occurrence of water scarcity periods)	-Ponds are of small size, storing insufficient water for dry season usage -Structures are not really constructed for the purpose of water harvesting and storage -No defined maintenance plan (issues of common goods)	- Rehabilitate/enlarge ponds to store water year-round - Improve trees and grasses cover around dams/ponds to reduce insolation and evaporation, stabilize the water point and reduce the siltation - Possibly avoid free livestock access and trampling from all directions
	Bore holes Open wells			Use solar or wind energy to power bore-holes for multipurpose usages

3.6. Effectiveness of conservation practices in the communities in Yobe State

Table 11. Effectiveness of SWC practices as observed in the surveyed sites in Yobe State

CDA / VA	Adopted measures	Weakness points (farmer perception)	Technical issues (expert evaluation)	Recommended improvement
Dogonkuka, Jimbam, Laye	Manuring	Insufficient quantity of manure	-Part of the manure is washed away by surface runoff/sheet erosion -Manure is not effectively incorporated to the soil and mineralized for crops -Manure is of poor quality due to pollutants (plastic residues)	-Proceed to composting for more efficient manure management -Adopt application of compost in planting holes/points to reduce losses
Dogonkuka, Laye	Crop rotation	-/-	Inadequate rotation (e.g., use of same crop types sometimes like cereals-cereals or leguminous-leguminous)	Improve the rotation using appropriate species combination (e.g. Nitrogen-fixing species with cereals on regular patterns)
	Contour ploughing	Need supplementary costs for contouring	Sometimes, the ploughing is made along the contour, but without ridging, making the soil loose and prone to runoff/erosion	Combine tie ridging and contour ridging associated with earth bunds consolidated with grasses (Vetiver or Gamba), for more effectiveness
Dogonkuka, Jimbam, Laye	Tree planting/Wood lots	Illegal cutting and bushfire are challenges	-There is not enough care on planted trees and established woodlots -Planting does not cover large areas	-Plant fast growing trees having good root systems -Convert waste lands (severely eroded) into community woodlots (benefits: restore lands and provide firewood)
Dogonkuka	Gamba grass planting	-Annual maintenance is required -Competition for nutrients with crops -Reduction of available land size for cropping	-Grasses are planted without any supporting structure (earth bund, etc.) -The patterns of the planted grasses are often not effective	-Associate the grass planting with earth bunds for more effectiveness -Improve the grass density to increase effectiveness
Dogonkuka, Jimbam	Sand bags	-Need annual maintenance (inputs and labor) -Poor effectiveness in controlling erosion	-The bags used are of poor quality, and are degraded in short time -The size and patterns of the structures are often not appropriate to control the gully development and runoff	-Placement of the sand bags should be effective in plugging the gully (covering its width and depth) -Use bags of good quality (resistant materials)

			-No vegetative measure is associated to the structure, making its unsustainable	
Dogonkuka	Abandonment associated to assisted natural regeneration	-Reduction of land availability -Supplementary labor for monitoring the fallowed lands	Free grazing is affecting the effectiveness of the fallowing	-Plant cover crops (e.g. Mucuna or similar leguminous) on plots set to fallow -Reduce the risks of illegal grazing using fencing
Laye	Intercropping	-/-	-Too many different crops on the same plot -Sometimes, intercropping is not properly done in terms of species combination, and the species location on the ridges	-The intercropping should respect some minimum density (space between different crops) -Use appropriate combination of crop types to avoid soil nutrient depletion -Improve cropping and rotate crop using appropriate species combination (e.g. mixing the Nitrogen-fixing species with cereals on regular patterns)
	Earth embankments	-Need annual maintenance labor -Not easy to construct them over large areas	Annual maintenance from the land users (induced by instability of the structure)	-Provide regular maintenance of the bunds (as width and height) -Combine vegetative measures to sustain the embankments

Table 12. Effectiveness of WH systems as observed in the surveyed sites in Yobe State

CDA / VA	**Adopted measures**	**Weakness points (farmer perception)**	**Technical issues (expert evaluation)**	**Recommended improvement**
Jimbam Dogonkuka	Dams/Ponds for animal use	Water shortage occurs some short period after the rainy season	-No management plan of ponds (issues of common pools) -Dams/Ponds do not have large size to enable longer storage of water	-Rehabilitate/enlarge ponds to store water year-round -Establish ponds/dams on suitable sites (cross streams, gullies/runoff ways, lowlands) to increase water harvesting potential -Possibly avoid free livestock access and trampling from all directions - Avoid the damping of wastes and other solid materials in the dam
Jimbam	Individual containers, for animal and domestic use	The containers are not large enough to cover water scarcity periods	Small size and insufficient number of containers at household level	Improve the capacity of the containers or their number to store more water, use community systems to store more water

3.7. General recommendations on water harvesting practices

In general water harvesting practices for both animal and human consumptions include the following:

(i) Surface water harvesting practices

- Ponds and borrow pits
- Constructed dams
- Rivers, in some cases (as the rivers dry up during the dry season)

(ii) Groundwater harvesting practices

- Hand pumps
- Solar powered boreholes
- Wind mills (rarely observed in the visited areas)

(iii) Rainfall harvesting practices

- Individual containers (tanks or constructed small reservoirs) for top roof water harvesting
- Small community reservoirs (cement-concrete reservoirs, mostly near mosque and community gathering points)

All the practices for water (surface or ground) harvesting have similar characteristics across the communities. In addition to having similar designs, they experience similar challenges in terms of maintenance, management, water shortage during acute dry season and insufficient supply with regards to the high demand of the communities. However, the situation seems less acute in some areas of Jigawa, Zamfara and Sokoto States, naturally benefiting from high surface water availability (permanent rivers, lakes/dams). Based on these issues, the following recommendations are suggested for improving the water availability in the communities.

- **Surface WH systems, especially ponds and borrow pits:**

The current systems of surface water harvest (from runoff or directly from rain) should be improved as they are mostly natural, except some borrow pits. Aim should be to increase the storage capacity and availability of water for use year-round. In addition, it is important to increase water harvesting potential by constructing new ponds or dams on suitable sites (cross streams, heavy gullies/runoff ways, lowlands) based on participatory approaches.

Furthermore, it is important to sustain all the WH systems by planting trees and/or grasses around the dams/ponds in order to reduce insolation and evaporation, and stabilize the banks of water points. Other multipurpose trees can be planted in the immediate neighborhood of the WH points, improving the greening the landscape and providing other climate and land related services.

Finally, it is important to regulate the access to water points to possibly avoid free livestock access and trampling from all directions The regulation of access to the water points could be enhanced by providing access zones at each water point.

Local communities should develop and operate simple management plans of surface water points such as ponds, dams, currently experiencing the tragedy of common pools. This will reduce the trampling of animals anyhow into the water bodies, making its use more efficient and benefit to all users.

- **Groundwater harvesting**

Given the high depth of the groundwater table in some sites, and to reduce human energy load to pump water, it is recommended to improve the use of renewable and clean energy sources (eg. solar, wind) to power bore-holes for ground water harvesting for multipurpose uses.

Apart from increasing the surface water availability, good practices of surface WH can improve the artificial recharge of the ground water. For that purpose, it is important to improve the collection of surface runoff through recharge structures likes recharge pits, recharge trenches, check dams, or tube wells, etc. to recharge aquifers.

- **Rain water harvest**

One of the observed good practices of WH is the roof top water collection in containers for multiple uses. Therefore, it is important to improve the capacity of the containers and/or their number to store more water from roof tops during rainfall events. These containers can be household-owned or community-owned systems to store more water for various uses.

4. Matrix of Options and some characteristics for 16 target communities in 6 States

4.1. MO for communities in Jigawa State

The MO tables can be interpreted on the basis of the analysis summarized with the ET tables.

Table 13. MO for Dagwaje community, Jigawa State.

Issues	Current Practices	Advised improvement	Advised local import	Advised international import
a. Soil and Water Conservation (SWC)				
Wind erosion & deposition	Planting holes	- Provide living structure (in rows crossing the farm) or fences (at farm edge) to abate wind velocity and reduce sediment deposition - use local tree/shrub species - Identify hotspot locations for tree planting (e.g., sand dunes at risk of being destabilized by cropping practices)	Leaving crop residues on-site - (as in Badau VA) Planting of cover species and Ron palm (like in Yautabaki VA)	Tree plantation (windbreak/sand dune stabilization; multi-purpose trees) as in WOCAT 53 and WOCAT 54) Grass reseeding (WOCAT 46)
	Boarder planting (hedge rows)	- Improve the structure of the hedge rows by multiplying the number of rows (instead of a unique line) - Use multipurpose species (multiple benefits) with different biological types (trees, shrubs, grass) to maintain the structure of the hedges at different levels	-/-	*Jatropha curcas* hedge (WOCAT 30)
Gully erosion	Planting Gamba grasses	- Need of improving the spot density and alignment on regular patterns to improve effectiveness	Planting vetiver grasses (like in Baawa VA), or Gamba grasses (like in Dogonkuka)	-/-
Soil infertility	Manuring	- Proceed to manure management and composting at farm for more efficiency - Avoid the mixture of domestic wastes such as plastics to reduce soil pollution	Planting leguminous species (cowpea, groundnut) as in Masama VA	Composting associated with planting pits (WOCAT 1)
	Mulching	- Leave crop residues on site, but plough them after harvest to secure organic matter input to soil	Leaving crop residues on-site (as in Badau VA)	-/-
	Association of fallow and	- Plant cover crops (e.g. Mucuna or similar leguminous) on plots set to fallow	Practice is well done, should be out-scaled to peers.	-/-

	Gamba grass planting	- Minimize the risks of illegal grazing using fencing	Assisted fallowing as in Dogonkuka VA	
	Intercropping (millet/ground nut)	- Crop rotation or modified relay farming instead of fallowing	-/-	-/-
Lack of soil moisture	Ridging	- Ridging should always be along the contour lines - Cross-ridges (ties) could be associated to main ridges to improve water harvest and infiltration	-/-	Micro-catchments and ponds (WOCAT 14)
Lack of firewood	woodlots	- Develop a community nursery	-/-	-/-
b. Water harvesting (WH)				
Water shortage for animal drinking	Ponds	- Enlarge and transform ponds to store water year-round - Establish ponds/dams on suitable sites (cross streams, gullies/runoff ways, lowlands) to increase water harvesting potential - Plant trees and grasses around dams/ponds to reduce insolation and evaporation - Possibly avoid free livestock access and trampling from all directions	Dams (like in Dogonkuka VA) Animal water drinking point under rehabilitation in Kebbe (Sokoto)	Dams (WOCAT 34) Runoff / flood water farming (WOCAT 16)
	Wells	Need alternative energy for powered pumps	Reticulated watering point from solar powered bore hole (such as in Kukawa)	-/-

Table 14. Relevant data from survey for Dagwaje

Some characteristics	**Dagwaje**
Land degradation	Wind erosion & particle deposition, Soil infertility, Water shortage for animal drinking, Pest & Diseases
Main rainfed crops	Millet, Sorghum, Groundnut, Beans, Sesame, Sesame
Main irrigated crops	No
Livestock number in the community	2650
Livestock species	Cow, sheep, goat, poultry
Multipurpose species on farm	*Baobab, Neem, locust beans, Balanites aegyptiaca*

Average household size	6
Land tenure in rangelands	No
Pasture management	No
Land tenure in forests	No
Forest management	No
Communal structure of land governance	No
Presence of nomadic herders	Seasonal
Estimated livestock of nomadic herders	16000
Surface water management	Ponds
Source of drinking water for human	Wells, Hand pumps, Solar bore holes
Source of drinking water for livestock	Wells, Hand pumps, Solar bore holes
Water shortage period	February-May
Groundwater table depth (m)	20
Surface water availability	Good
Surface water quality	Variable (poor to good drinking water)
Traditional soil name	Rarayi or Kassa
Modern soil name	Sandy soil
Soil depth	Shallow to moderately deep
Topsoil texture	Coarse
Subsoil texture	Coarse
Topsoil organic matter	Low
Soil structure	Weak

Table 15. MO for Gana-Kaya community, Jigawa State

Issues	Practiced	Advised improvement	Advised local import	Advised international import
a. Soil and Water Conservation (SWC)				
Gully erosion	Stone bunds	- Increase the height and tightness of the stone bunds - Replicate the number of stone lines to abate the flow velocity - Always associate a vegetative component (planting shrubs or grasses) to support the structures	Contours bunds (embankments) as in Barangawa VA	Soil bund & Fanya Juu combined & vegetated (WOCAT 15)
	Sand bags for gully plugging	- Use bags of good resistance to avoid the destruction (induces pollution) replace them on yearly basis. or stone - Dispose the sand bags across the slope/gully to abate flow and stop sediment to replenish the soil level - Collectively with neighbor farmers, address erosion issue at gully initiation point	Contours bunds (embankments) as in Barangawa VA Earth embankment associated with shrub planting as in Laye (Yobe)	Stone wall check dam (WOCAT 31)
	Planting grasses & shrub fencing for gully erosion control	- Replace the dry shrubs by living ones - Plant regular rows of shrubs that can resist to runoff - Address erosion issue at gully initiation point	Planting vetiver grasses (like in Baawa VA), or Gamba grasses (like in Dagwaje or Dogonkuka VA)	Jatropha curcas hedge (WOCAT 30)
	Planting grasses associated with shrubs	-	Practice is well done, should be out-scaled to peers	
Soil infertility	Manuring	- Proceed to manure management and composting at farm for more efficiency - Avoid the mixture of domestic wastes such as plastics to reduce soil pollution	Planting leguminous species (cowpea, groundnut) as in Masama VA	Composting associated with planting pits (WOCAT 1)
		- Leaving crop residues on site and ploughing	Leaving crop residues on-site (as in Badau VA)	Composting associated with planting pits (WOCAT 1)
		- Crop rotation/mixed cropping	-/-	-/-
		- Fallowing	Assisted fallowing as in Dogonkuka VA	Assisted Natural Regeneration of Degraded Land (WOCAT 21)

Lack of firewood	**Woodlots**		Practice is well done, should be out-scaled to peers	
b. Water harvesting (WH)				
Water shortage for livestock	Ponds	- Enlarge and transform ponds to store water year-round - Establish ponds/dams on suitable sites (cross streams, gullies/runoff ways, lowlands) to increase water harvesting potential - Plant trees and grasses around dams/ponds to reduce insolation and evaporation - Possibly avoid free livestock access and trampling from all directions	Dams (such as in Dogonkuka VA) Animal water drinking point under rehabilitation in Kebbe (Sokoto)	Dams (WOCAT 34) Check dam ponds (WOCAT 33) Runoff / flood water farming (WOCAT 16)
	Solar powered bore holes	- Increase number of bore holes powered by solar energy to avoid water shortage - Permanent maintenance of the powering systems	Reticulated watering point from solar powered bore hole (such as in Kukawa)	-/-
	Open wells	Use alternative energy (solar or wind) to power pumps	-/-	-/-

Table 16. Relevant data from survey for Gana-Kaya

Some characteristics	**Gana-Kaya**
Land degradation	Gully erosion, Sheet erosion, Soil infertility
Main rainfed crops	Millet, Sorghum, Groundnut, Cowpea, Sesame
Main irrigated crops	No
Livestock number in the community	28 000
Livestock species	Cattle, Sheep, Goats, Poultry
Multipurpose species on farm	Locust beans, Baobab, Neem
Average household size	14
Land tenure in rangelands	Governmental
Pasture management	Free access
Land tenure in forests	Governmental
Forest management	Regulated access
Communal structure of land governance	Youth guarders
Presence of nomadic herders	Yes, occasional
Estimated livestock of nomadic herders	30000

Surface water management	Ponds
Source of drinking water for human	Wells, Hand pumps
Source of drinking water for livestock	Ponds, Wells, Hand pumps
Water shortage period	February-May
Groundwater table depth (m)	25
Surface water availability	Good
Surface water quality	Poor drinking water
Traditional soil name	Fararkasa + Daka + Jigawa
Modern soil name	Sandy soil, clay soil
Soil depth	Shallow
Topsoil texture	Medium to coarse
Subsoil texture	Medium to coarse
Topsoil organic matter	Low
Soil structure	Weak to moderate

Table 17. MO for Kukawa community, Jigawa State

Issue	Practiced	Advised improvement	Advised local import	Advised international import
a. Soil and Water Conservation (SWC)				
Wind erosion & deposition	Leaving crop residues, and weeds, on-site;	- Mentioned by farmers but not observed during field visit. However, it is recommended to improve the recycling of organic matter by ploughing back the residues	Leaving crop residues on-site (as in Badau VA) Planting of cover species and Ron palm (like in Yautabaki VA)	Grass reseeding (WOCAT 46) Sand dune stabilization (WOCAT 53; WOCAT 54)
	Association of crop residues and cover plants	-	Practice is well done, should be out-scaled to peers	
	Late land preparation	- Improve soil structure and stability by enhancing organic matter content through tree & shrub planting	Agroforestry associated with earth bunds (like in Kebbe CDA)	Grass reseeding (WOCAT 46) Tree plantation (windbreak/sand control; multi-purpose trees) as in WOCAT 53

	Planting holes	- Provide living structure (in rows crossing the farm) or fences (at farm edge) to abate wind velocity and reduce sediment deposition - Identify hotspots (e.g., sand dunes) in the landscape and stabilize them using vegetative measures	Leaving crop residues on-site (as in Badau VA)	Sand dune stabilization (WOCAT 53; WOCAT 54)
Gully erosion	Filling gullies with shrubs	- If not integrated with sand bagging or other structural or vegetative measures, this cannot be effective.		
Soil infertility	Mulching	- Proceed to manure management and composting at farm for more efficiency - Reduce contamination with plastics by selectively collecting them on farm to reduce soil pollution	Planting leguminous species (cowpea, groundnut) in Masama VA	Composting associated with planting pits (WOCAT 1)
			Association of fallow and Gamba grass planting as in Dagwaje	Improved millet varieties (earliness)
Lack of grazing land	Free grazing + Grazing on stubbles + fodder from pruning	- Establish managed communal grazing land - Improved grazing management and fodder production - Establish feedlots		Community supported pasture and rangeland rehabilitation works (WOCAT 45) Grass reseeding (WOCAT 46)
Lack of firewood and multipurpose trees	Nursery for tree planting	-		
b. Water harvesting (WH)				
Water shortage for animal drinking	Ponds	- Enlarge and transform ponds to store water year-round - Plant trees and grasses around dams/ponds to reduce insolation and evaporation - Possibly avoid free livestock access and trampling from all directions	Dams for animal drinking (such as in Dogonkuka VA)	Dams (WOCAT 34) Check dam ponds (WOCAT 33) Runoff / flood water farming (WOCAT 16)
	Solar powered bore holes	- Increase number of bore holes powered by solar energy to avoid water shortage - Permanent maintenance of the powering systems	This reticulated watering point from solar powered bore hole is a well-done practice, should be out-scaled to peers	-/-

Table 18. Relevant data from survey for Kukawa

Some characteristics	Kukawa
Land degradation	Wind erosion & particle deposition, Soil infertility, Water shortage for animal drinking
Main rainfed crops	Millet, Sorghum, Sesame, Cowpea, Watermelon, Groundnut
Main irrigated crops	No
Livestock number in the community	126000
Livestock species	Cow, sheep, goat, poultry
Multipurpose species on farm	Neem, Locust beans, baobab, Piliostigma
Average household size	7
Land tenure in rangelands	Government-owned
Pasture management	Free access
Land tenure in forests	No
Forest management	No
Communal structure of land governance	Forest guarders committee (10 members)
Presence of nomadic herders	Yes, occasional
Estimated livestock of nomadic herders	2500
Surface water management	Ponds
Source of drinking water for human	Ponds, Bore hole, Pumps
Source of drinking water for livestock	Hand pumps, Bore holes
Water shortage period	February-April
Groundwater table depth (m)	20
Surface water availability	Good
Surface water quality	Poor drinking water
Traditional soil name	Bulbuldi or Rarayi, Yashi or Katti
Modern soil name	Sandy soil
Soil depth	Very shallow to shallow
Topsoil texture	Medium
Subsoil texture	Medium
Topsoil organic matter	Low
Soil structure	Weak

4.2. MO for communities in Katsina State

Table 19. MO for Garu community, Katsina State

Issues	Current Practices	Advised improvement	Advised local import	Advised international import
a. Soil and Water Conservation (SWC)				
Gully erosion, Sheet erosion	Vetiver grass planting	- Increase the grass density and the length of the planted rows in association with earth/stone bunds - develop long term measures (e.g. diversion channel) that address the runoff at its initiation point - address gully at initiation point	Planting vetiver grasses (like in Baawa VA), integrating the advised improvements Contours bunds (embankments) as in Barangawa VA	Reinforced terraces for stone walls (WOCAT 36) Jatropha curcas hedge (WOCAT 30)
	Planting cover species (*Datura arborea*) & Ron palm (*B. aethiopum*)	- Increase the species density and the length of the planted rows in association with earth/stone bunds for more effectiveness	-/-	Soil bund & Fanya Juu combined & vegetated (WOCAT 15)
	Sand bags for gully plugging	- Build check dams - Use bags of good resistance to avoid the destruction (also inducing pollution) and replace them on yearly basis. - Dispose the sand bags across the slope/gully to abate flow and stop sediment to replenish the soil level - Collectively with neighbor farmers, address erosion issue at gully initiation point - Control runoff formation/concentration upstream	Earth embankment associated with shrub planting in Laye (Yobe)	Jatropha curcas hedge (WOCAT 30) Stone wall check dam (WOCAT 31)
	Combination of sand bagging, stone bunds, and ridge ploughing	- Adopt contour ploughing - develop long term measures (e.g. diversion channel sustained with vegetative measure) that address the runoff at its initiation point	Earth embankment associated with shrub planting in Laye (Yobe	Jatropha curcas hedge (WOCAT 30) Stone wall check dam (WOCAT 31)

Soil infertility	Manuring	- Manure management and composting at farm for more efficiency - Application of compost in planting holes/points to reduce losses	Planting leguminous species (cowpea, groundnut) in Masama VA	Composting associated with planting pits (WOCAT 1)
	Intercropping Composting Mixed cropping	- Plant cover crops (e.g. Mucuna or similar leguminous) on plots set to fallow for improving organic matter availability - Improve the composting systems to minimize the loss of organic matter	-/-	Composting associated with planting pits (WOCAT 1)
	Natural regeneration	- Assist the natural regeneration by maintaining the regrowth of plants - Improve tree/shrub density by planting multipurpose trees (agroforestry)	-/-	Assisted Natural Regeneration of Degraded Land (WOCAT 21)
	Leaving crop residues	- Plough the crop residues back after harvest to secure organic matter input to soil	Leaving crop residues on-site (as in Badau VA)	-/-
b. Water harvesting (WH)				
Water shortage for both animal and human consumption	Ponds, Streams Boreholes	- Establish ponds/dams of appropriate size on suitable sites (cross streams, gullies/runoff ways, lowlands) to increase water harvesting potential - Plant trees using appropriate species around the established ponds/dams. Planted trees should be sustained by half-moons/micro catchments to ensure successful growth of seedlings - Use solar or wind energy to power bore-holes for multipurpose usage	Dams for animal drinking (such as in Dogonkuka VA) Reticulated watering point from solar powered bore hole (such as in Kukawa)	Dams (WOCAT 34) Runoff / flood water farming (WOCAT 16)

Table 20. Relevant data from survey for Garu community

Some characteristics	**Garu**
Land degradation	Gully erosion, Sheet erosion, Soil infertility
Main rainfed crops	Maize, Sorghum, Cotton, Cowpea
Main irrigated crops	Vegetables (Onion, Carot, Tomato, Occro, etc.)
Livestock number in the community	Not estimated
Livestock species	Cattle, Goat, Sheep, Poultry
Multipurpose species on farm	Neem, Locust bean
Average household size	10

Land tenure in rangelands	Communal
Pasture management	Free access
Land tenure in forests	Communal
Forest management	Free access
Communal structure of land governance	No
Presence of nomadic herders	Occasional
Estimated livestock of nomadic herders	20000
Surface water management	Borrow pits/ponds
Source of drinking water for human	Hand pumps, Bore holes
Source of drinking water for livestock	Ponds, Hand pumps
Water shortage period	February-May
Groundwater table depth (m)	20
Surface water availability	Excess (high rainfall)
Surface water quality	Dominantly poor drinking water
Traditional soil name	Not mentioned
Modern soil name	Clay soil
Soil depth	Moderately deep
Topsoil texture	Fine/heavy
Subsoil texture	Fine/heavy
Topsoil organic matter	Medium
Soil structure	Moderate

Table 21. MO for Kofa community, Katsina State

Issues	Current Practices	Advised improvement	Advised local import	Advised international import
a. Soil and Water Conservation (SWC)				
Gully erosion	Sand bags for gully plugging	- Build check dams - Use bags of good resistance to avoid the destruction (also inducing pollution) and replace them on yearly basis - Address the gully erosion at the initiation point - develop long term measures (e.g. diversion channel sustained with vegetative measure) that address the runoff at its initiation points	Earth embankment associated with shrub planting in Laye (Yobe	Jatropha curcas hedge (WOCAT 30) Stone wall check dam (WOCAT 31)
Gully and sheet erosion	Stone bunds Combination of stone bunds and sand bagging	- Associate a vegetative measure (e.g. shrubs/trees planting) to sustain the practice - Adopt contour ploughing and integrate water diversion measures sustained by vegetative measures	Contours bunds (embankments) as in Barangawa VA	Soil bund & Fanya Juu combined & vegetated (WOCAT 15) Reinforced terraces for stone walls (WOCAT 36)
	Combination of sand bags, stone bunds, shrub planting and ridge ploughing	- ploughing along contour, even though waterlogging was reported on flat terrain and very gentle slopes	Practice is well done, should be out-scaled to peers	
	Water diversion	- Integrate the water diversion to the above measures - Associate a vegetative measure (e.g. shrubs/trees planting) to sustain the practice - Adopt contour ploughing along with water diversion measures to target sheet and gully erosion at farm level	Earth embankment associated with shrub planting in Laye (Yobe)	-/-
Soil infertility	Manuring	- Manure management and composting at farm for more efficiency - Application in planting holes/points to reduce losses	Planting leguminous species (cowpea, groundnut) in Masama VA	Composting associated with planting pits (WOCAT 1)
b. Water harvesting (WH)				

Animal drinking points	Ponds	- Enlarge and transform ponds to store water year-round - Establish ponds/dams on suitable sites (cross streams, gullies/runoff ways, lowlands) to increase water harvesting potential - -Plant trees and grasses around dams/ponds to reduce insolation and evaporation. Planted trees should be sustained by half-moons/micro catchments to ensure successful growth of seedlings - Possibly avoid free livestock access and trampling from all directions	Dam for animal drinking (such as in Dogonkuka VA)	Dams (WOCAT 34) Runoff / flood water farming (WOCAT 16)
Water shortage for domestic use	Bore holes & Open wells	- Provide equipment that can be sustainably maintained by the communities - Use solar or wind energy to power bore-holes for multipurpose usages	Reticulated watering point from solar powered bore hole (as in Kukawa)	-/-

Table 22. Relevant data from survey for Kofa community

Some characteristics	Kofa
Land degradation	Gully erosion, Soil infertility, Animal drinking points, Water shortage for domestic use
Main rainfed crops	Sorghum, Soyabean, Cowpea, Cotton
Main irrigated crops	No
Livestock number in the community	8000
Livestock species	Cow, Goat, Sheep, Poultry
Multipurpose species on farm	Neem, Tamarindus, Locust beans, Piliostigma, Diospyros
Average household size	12
Land tenure in rangelands	Communal
Pasture management	Free access
Land tenure in forests	Governmental
Forest management	Restricted
Communal structure of land governance	Communal forest guarders
Presence of nomadic herders	Occasional
Estimated livestock of nomadic herders	Not estimated
Surface water management	Ponds, Dams
Source of drinking water for human	Hand pumps, Bore holes

Source of drinking water for livestock	Ponds, Dams, Hand pumps
Water shortage period	March - May
Groundwater table depth (m)	25
Surface water availability	Poor to good
Surface water quality	Poor drinking water, for irrigation
Traditional soil name	Dandakuwa
Modern soil name	Sandy clay soil
Soil depth	Moderately deep
Topsoil texture	Fine/heavy
Subsoil texture	Fine/heavy
Topsoil organic matter	Low
Soil structure	Moderate

Table 23. MO for Baawa community, Katsina State

Issues	Current Practices	Advised improvement	Advised local import	Advised international import
a. Soil and Water Conservation (SWC)				
Gully erosion	**Vetiver grass planting, to stabilize farm edge gully**	- Increase the grass density and the length of the planted rows in association with earth/stone bunds - Adopt contour ploughing - Address gully at initiation point	Practice is well done, should be out-scaled to peers after integrating advised improvements Contours bunds (embankments) as in Barangawa VA	Reinforced terraces for stone walls (WOCAT 36) Soil bund & Fanya Juu combined & vegetated (WOCAT 15)
	Sand bags for gully plugging	- Build check dams - Use bags of good resistance to avoid the destruction (also inducing pollution) and replace them on yearly basis - Address the gully erosion at the initiation point - develop long term measures (e.g. diversion channel sustained with vegetative measure) that address the runoff at its initiation points	Earth embankment associated with shrub planting as in Laye (Yobe)	Jatropha curcas hedge (WOCAT 30) Stone wall check dam (WOCAT 31)
Soil infertility	Manuring	- Manure management and composting at farm for more efficiency	Planting leguminous species (cowpea,	Composting associated with planting pits (WOCAT 1)

			groundnut) as in Masama VA	
	Mulching	- Proceed to composting at farm for more efficiency and reduce uptake of residues by illegal grazing - Planting cover crops (such as Mucuna or similar leguminous) - Ploughing residues back to soil to secure organic matter input to soil		
	Composting	- Plant cover crops (e.g. Mucuna or similar leguminous) on plots set to fallow to enhance organic matter availability - Improve the composting systems to minimize the loss of organic matter	-/-	Composting associated with planting pits (WOCAT 1)
	Intercropping, mixed cropping	- Ensure the appropriate combination of crop species to avoid competition for nutrient uptake	-/-	-/-
	Natural tree regeneration (on farm	- Improve tree/shrub density by planting multipurpose trees (agroforestry)	Agroforestry associated with earth bunds as in Kebbe	Parkland Agroforestry System (WOCAT 20)
Multiple purposes	Nursery for tree planting (failed)	- Adopt drought tolerant plant species for raising nurseries - Nurseries should be established in water-secured areas (e.g. near permanent WH points such boreholes, open dug wells) - Possibly encourage household-owned nursery establishment to secure success through watering by household waste water		
Soil infertility, soil moisture	Ridge ploughing	- Ridging should always be along the contour lines - Cross-ridges (ties) could be associated to main ridges to improve water harvest and infiltration	-/-	-/-
b. Water harvesting (WH)				
Animal drinking points	Ponds	- Enlarge and transform ponds to store water year-round - Establish ponds/dams on suitable sites (cross streams, gullies/runoff ways,	Dams for animal drinking (such as in Dogonkuka VA)	Dams (WOCAT 34) Runoff / flood water farming (WOCAT 16)

		lowlands) to increase water harvesting potential - Associate tree and grasses planting to dams/ponds to reduce insolation effects and evaporation. Planted trees should be sustained by half-moons/micro catchments to ensure successful growth of seedlings		
Water shortage for domestic use	Bore holes & Open wells	- Provide equipment that can be sustainably maintained by the communities - Use wind or sun as alternative sources of energy to power bore-holes	Reticulated watering point from solar powered bore-hole (in Kukawa)	-/-

Table 24. Relevant data from survey for Baawa community

Some characteristics	Baawa
Land degradation	Gully erosion, Soil infertility, Animal drinking points
Main rainfed crops	Sorghum, Cowpea, Millet, Hibiscus
Main irrigated crops	No
Livestock number in the community	Over 5000
Livestock species	Cow, Sheep, Goat, Poultry
Multipurpose species on farm	*Piliostigma reticulata*, *Combretum sp*, Neem
Average household size	13
Land tenure in rangelands	Governmental
Pasture management	No pasture
Land tenure in forests	Governmental
Forest management	Regulated by government
Communal structure of land governance	Communal land guarders
Presence of nomadic herders	Yes, occasional
Estimated livestock of nomadic herders	30 - 40 camels
Surface water management	Seasonal streams
Source of drinking water for human	Bore hole, Hand pumps
Source of drinking water for livestock	Bore hole, Hand pumps
Water shortage period	January - May
Groundwater table depth (m)	24
Surface water availability	Poor/none
Surface water quality	Dominantly poor drinking water

Traditional soil name	Hako (i.e. crust pan), Jigawu (i.e. loose soil)
Modern soil name	Sandy soil
Soil depth	Shallow
Topsoil texture	Coarse
Subsoil texture	Medium
Organic matter in topsoil	Low
Soil structure	Weak

4.3. MO for communities in Kebbi State

Table 25. MO for Masama, Kebbi State

Issues	Current Practices	Advised improvement	Advised local import	Advised international import
a. Soil and Water Conservation (SWC)			**b.**	**c.**
Gully erosion, sheet erosion	Planting grasses (*Datura arborea*)	- Improve planting patterns (in lines across the slope) and density of grass spots, preferably along soil bunds - Consider the whole area under erosion as priority area for planting. Preferably, integrate structural measures (soil/stone bunds) with shrubs (e.g. Jatropha) to plug the gullies - Control the gully initiation points using vegetative measures (grass planting associated to soil bunds)	Planting vetiver grasses (like in Baawa VA), and integrate the advised improvements	Soil bund & Fanya Juu combined & vegetated (WOCAT 15) Dawa-Chea Traditional Checkdam (WOCAT 7)
	Sand bags	- Placement of sand bags of adequate size should be effective in plugging the gully (if well distributed along its width and depth) - Use bags of good quality (resistant materials) - Progressively restore the lands by associating vegetative measures (planting shrubs like Jatropha)	Contours bunds (embankments) as in Barangawa VA Earth embankment associated with shrub planting in Laye (Yobe)	Soil bund & Fanya Juu combined & vegetated (WOCAT 15) Dawa-Chea Traditional Checkdam (WOCAT 7)
	Contour ridges/contour ploughing	- Combine the contour ridging with earth bunds stabilized with grasses (Vetiver or Gamba, Banana) or trees (Jatropha or neem) for more effectiveness - Control gully initiation points using vegetative measures (grass planting associated to soil bunds) - Undertake technical trainings to the famers on the identification of contours and contour ploughing/ridging	Contours bunds (embankments) as in Barangawa VA	Soil bund & Fanya Juu combined & vegetated (WOCAT 15) Large semi-circular stone bunds (WOCAT 32)
	Contour bunds	- Undertake a general maintenance of the bunds (as width and height)	Contours bunds (embankments) as in Barangawa VA	Soil bund & Fanya Juu combined & vegetated (WOCAT 15)

		- Re-establish the supporting vegetative measures and expand planting of trees/shrubs along the bunds - Undertake peer sensitization on this technique adopted by a single farmer of the community based on the success of this pioneering experience. Integrate advised improvements		
Wind erosion and deposition	No practice	- Establishment of community nurseries for shelterbelts/windbreaks - Provide living structure (in rows crossing the farm) or fences (at farm edge) to abate wind velocity and reduce sediment deposition - Identify hotspots (e.g., sand dunes) in the landscape and stabilize them using vegetative measures	Planting of cover species and Ron palm (as in Yautabaki VA) Agroforestry associated with earth bunds as in Kebbe CDA Leaving crop residues on-site (as in Badau VA)	Sand dune stabilization (WOCAT 53, WOCAT 54)
Soil infertility	Manuring	- Manure should be managed in composting for more efficiency - Adopt the application of produced compost in planting holes/points to reduce losses (rather than broadcasting) - Integrate with planting of leguminous species		Composting associated with planting pits (WOCAT 1)
	Composting (traditional)	- Improve traditional composting where practiced and associate planting pits for more efficiency and loss reduction	-/-	Composting associated with planting pits (WOCAT 1)
	Fallowing	- Adopt improved fallowing by enriching the fallow with planted leguminous trees or grasses - Protect the fallow against intensive grazing to ensure quick restoration	Assisted fallowing as in Dogonkuka VA	Rehabilitation of degraded lands (WOCAT 13) Area closure for rehabilitation (WOCAT 6)
	Planting leguminous species (cowpea, groundnut)	- - Since crop residues are hardly left on ground because of animal grazing, compost making and application can contribute improving soil structure and fertility	Awareness of role of leguminous in soil fertility is very important, the practice is to be encouraged	Composting associated with planting pits (WOCAT 1)
	Intercropping, Mixed-	Improve the mix cropping and rotation using appropriate species combination (e.g. mixing	-/-	Composting associated with planting pits (WOCAT 1)

	cropping, Crop rotation	the Nitrogen-fixing species with cereals on regular patterns)		
	Leaving crop residues on site	- Proceed to the ploughing back of the residues - Establishment of living fencing around the households and make available the plant residues for composting	Leaving crop residues on-site (as in Badau VA)	Composting associated with planting pits (WOCAT 1)
Soil infertility, soil moisture	Ridge ploughing	- Tie-ridging is advised in association to ridge ploughing to increase soil moisture	-/-	Soil bund & Fanya Juu combined & vegetated (WOCAT 15)
	Planting pits	- Make sure the pits are not dug at the same places every year to ensure a kind of rotation - Adopting the half-moon/micro-catchment technique could offer more effectiveness and reduce labor inputs	-/-	Use of organic matter (manure and compost) (WOCAT 19)
b. Water harvesting (WH)				
Soil water harvesting and moisture conservation	Half-moon	- Since the soil types are often loose, stabilize the soil bunds of the half-moon with vegetative measures	-/-	Micro-catchments and ponds (WOCAT 14)
Water shortage for animal and domestic use & human consumption	Ponds Dams	- Rehabilitate the existing ponds (e.g. use of lateritic concretes (basal) to reduce infiltration) to store water year-round - Plant trees and grasses around dams/ponds to reduce insolation and evaporation - Possibly avoid free livestock access and trampling from all directions	Dams for animal drinking (such as in Dogonkuka VA) Reticulated watering point from solar powered bore hole (such as in Kukawa)	Dams (WOCAT 34) Runoff / flood water farming (WOCAT 16)

Table 26. Relevant data from survey for Masama community

Some characteristics	Masama
Land degradation	Gully erosion, Sheet erosion, Wind erosion, Insufficient soil moisture, Water shortage
Main rainfed crops	Millet, Sorghum, Cowpea, Maize, Groundnut, Rice
Main irrigated crops	Rice, Sweet potato, Maize, Vegetables
Livestock number in the community	37000

Livestock species	Cattle, Goat, Sheep, Poultry
Multipurpose species on farm	Mango, Baobab, Banana, Locust beans, Vitex
Average household size	30
Land tenure in rangelands	Government
Pasture management	No regulation
Land tenure in forests	Forest reserves
Forest management	Regulated by community
Communal structure of land governance	No structure
Presence of nomadic herders	Seasonal
Estimated livestock of nomadic herders	7000
Surface water management	Streams, Dams
Source of drinking water for human	Streams and ponds
Source of drinking water for livestock	Open wells, bore holes, Hand pumps
Water shortage period	March-June
Groundwater table depth (m)	15
Surface water availability	Good
Surface water quality	Poor drinking water
Traditional soil name	Kunga
Modern soil name	Sandy loam
Soil depth	Shallow
Topsoil texture	Coarse
Subsoil texture	Coarse
Topsoil organic matter	Low
Soil structure	Moderate

Table 27. MO for Bui, Kebbi State

Issues	Current Practices	Advised improvement	Advised local import	Advised international import
a. Soil and Water Conservation (SWC)				
Gully erosion, sheet erosion	Contour ridges/contour ploughing	- Combine the contour ridging with earth bunds stabilized with grasses (Vetiver or Gamba or other locally available grasses) or shrubs (Jatropha) for more effectiveness	Contours bunds (embankments) as in Barangawa VA	Soil bund & Fanya Juu combined & vegetated (WOCAT 15)

		- Control gully initiation points using vegetative measures (grass planting associated to soil bunds)		Barreiras Vivas de Leucaena (WOCAT 37)
	Construction of soil bunds	- Undertake a general maintenance of the bunds (as width and height) - Establish, or restore, the vegetative measures and increase planting of trees/shrubs (along the bunds)	Contours bunds (embankments) as in Barangawa VA	Soil bund & Fanya Juu combined & vegetated (WOCAT 15) Dawa-Chea Traditional Checkdam (WOCAT 7)
	Placement of sand/stone bags for gully plugging	- Placement of the sand bags of adequate size should be effective in plugging the gully (covering its width and depth) - Use bags of good quality (resistant materials) - Progressively restore the lands by associating vegetative measures (planting shrubs like Jatropha)	Contours bunds (embankments) as in Barangawa VA Earth embankment associated with shrub planting as in Laye (Yobe)	Soil bund & Fanya Juu combined & vegetated (WOCAT 15) Dawa-Chea Traditional Checkdam (WOCAT 7)
	Planting of cover species (*Datura arborea, Hypomea sp*.) and grasses (Gamba, Vetiver)	- Improve planting patterns (in lines across the slope) and density of grass spots, preferably along soil bunds - Consider the whole area under erosion as priority area for planting. Preferably, integrate structural measures (soil/stone bunds) with shrubs (e.g. Jatropha) to plug the gullies - Whatever practices, it is important to control the gully initiation points using vegetative measures (grass planting associated to soil bunds)	Planting vetiver grasses (like in Baawa VA), integrating the advised improvements	Soil bund & Fanya Juu combined & vegetated (WOCAT 15) Dawa-Chea Traditional Checkdam (WOCAT 7)
Wind erosion and deposition	No practice	- Establishment of community nurseries for shelterbelts/windbreaks - Provide living structure (in rows crossing the farm) or fences (at farm edge) to abate wind velocity and reduce sediment deposition - Identify hotspots (e.g., sand dunes) in the landscape and stabilize them using vegetative measures	Planting cover species and Ron palm (as in Yautabaki VA) Agroforestry associated with earth bunds (as in Kebbe CDA) Leaving crop residues on-site (as in Badau VA)	Sand dune stabilization (WOCAT 53, WOCAT 54)

Soil infertility, soil moisture	Planting pits	- Make sure the pits are not dug at the same places every year to ensure a kind of rotation - Adopting the half-moon/micro-catchment technique could offer more effectiveness and reduce labor inputs	-/-	Composting associated with planting pits (WOCAT 1)
Soil infertility	Composting (traditional)	Improve the composting method and associate planting pits for more efficiency and loss reduction	-/-	Composting associated with planting pits (WOCAT 1)
	Leaving crop residues on site	- Proceed to the ploughing back of the crop residues if available; proceed to composting - Establishment of living fencing around the households and make available the plant residues for composting	Leaving crop residues on-site (as in Badau VA)	Composting associated with planting pits (WOCAT 1)
	Intercropping, Mixed-cropping, Crop rotation	- Improve the mix cropping and rotation using appropriate species combination (e.g. mixing the Nitrogen-fixing species with cereals on regular patterns)	-/-	Composting associated with planting pits (WOCAT 1)
Soil infertility and soil moisture	Ridge ploughing	- Tie-ridging is advised in association to ridge ploughing to increase water infiltration and soil moisture	-/-	Soil bund & Fanya Juu combined & vegetated (WOCAT 15)
b. Water harvesting (WH)				
Soil water harvesting and moisture conservation	Half-moon	- Since the soil type are often loose, stabilize the soil bunds of the half-moon with vegetative measures	-/-	Large semi-circular stone bunds (WOCAT 32)
	Tie-ridging	Associate tie-ridging to ridges to increase soil moisture conservation	-/-	Micro-catchments and ponds (WOCAT 14)
Water shortage for animal and domestic use	Ponds	- Rehabilitate the existing ponds (e.g. use of lateritic concretes (basal) to reduce infiltration) to store water year-round - Establish ponds/dams on suitable sites (cross streams, gullies/runoff ways, lowlands) to increase water harvesting potential - Plant trees and grasses around dams/ponds to reduce insolation and evaporation - Possibly avoid free livestock access and trampling from all directions	Dams for animal drinking (as in Dogonkuka VA) Reticulated watering point from solar powered bore hole (such as in Kukawa)	Dams (WOCAT 34) Runoff / flood water farming (WOCAT 16)

Table 28. Relevant data from survey for Bui community

Some characteristics	Bui
Land degradation	Gully erosion, Sheet erosion, Insufficient soil moisture
Main rainfed crops	Sorghum, Late millet, Groundnut, Millet, Cowpea, Rice
Main irrigated crops	Rice, Vegetables
Livestock number in the community	Not estimated
Livestock species	Cattle, Goat, Sheep, Donkey, Horse, Poultry
Multipurpose species on farm	Mango, Locust beans, Shea tree, Neem
Average household size	30
Land tenure in rangelands	Governmental
Pasture management	No
Land tenure in forests	Governmental
Forest management	Restricted access
Communal structure of land governance	Government Forest guarders
Presence of nomadic herders	Seasonal
Estimated livestock of nomadic herders	65000
Surface water management	Ponds
Source of drinking water for human	Open wells, Hand pumps, Bore holes
Source of drinking water for livestock	Open wells, Hand pumps, Bore holes
Water shortage period	May-June
Groundwater table depth (m)	24
Surface water availability	Excess
Surface water quality	Poor drinking water
Traditional soil name	Yashi
Modern soil name	Sandy soil
Soil depth	Shallow
Topsoil texture	Medium
Subsoil texture	Medium
Topsoil organic matter	Medium
Soil structure	Strong

Table 29. MO for Barangawa, Kebbi State

Issues	Current Practices	Advised improvement	Advised local import	Advised international import
a. Soil and Water Conservation (SWC)				
Gully erosion, sheet erosion	Planting Vetiver grasses	- Improve planting patterns (in lines across the slope) and density of grass spots, preferably along soil bunds - Consider the whole area under erosion as priority area for planting. Preferably, integrate structural measures (soil/stone bunds) with shrubs (e.g. Jatropha) to plug the gullies - Control the gully initiation points using vegetative measures (grass planting associated to soil bunds)	Planting vetiver grasses (like in Baawa VA), integrating the advised improvements	Soil bund & Fanya Juu combined & vegetated (WOCAT 15) Dawa-Chea Traditional Checkdam (WOCAT 7)
	Contour bunds (embankments)	- Undertake a general maintenance of the bunds (as width and height) - Combine with contour ridging; - Establish, or restore, the vegetative measures to stabilize the earth bunds, e.g., planting grasses along the bunds (Vetiver or Gamba or other locally available grasses), or shrubs (Jatropha), and increase planting of trees/shrubs (for more effectiveness) - Control gully initiation points using vegetative measures (grass planting associated to soil bunds)	Practice is well-done, scale-out to peers, integrating recommended improvements	Soil bund & Fanya Juu combined & vegetated (WOCAT 15) Barreiras Vivas de Leucaena (WOCAT 37)
	Placement of sand/stone bags for gully plugging	- Placement of the sand bags of adequate size should be effective in plugging the gully (covering its width and depth) - Use bags of good quality (resistant materials) - Progressively restore the lands by associating vegetative measures (planting shrubs like Jatropha)	Earth embankment associated with shrub planting as in Laye (Yobe)	Soil bund & Fanya Juu combined & vegetated (WOCAT 15) Dawa-Chea Traditional Checkdam (WOCAT 7)
	Planting of cover species (*Datura*	- Improve planting patterns (in lines across the slope) and density of grass spots, preferably along soil bunds	Planting vetiver grasses (like in Baawa VA), integrating the advised improvements	

	arborea, Hypomea sp.) and grasses (Gamba, Vetiver)	- Consider the whole area under erosion as priority area for planting. Preferably, integrate structural measures (soil/stone bunds) with shrubs (e.g. Jatropha) to plug the gullies - Whatever practices, it is important to control the gully initiation points using vegetative measures (grass planting associated to soil bunds)		
Wind erosion and deposition	No practices	- Establishment of community nurseries for shelterbelts/windbreaks - Provide living structure (in rows crossing the farm) or fences (at farm edge) to abate wind velocity and reduce sediment deposition - Identify hotspots (e.g., sand dunes) in the landscape and stabilize them using vegetative measures	Planting of cover species and Ron palm (as in Yautabaki VA) Agroforestry associated with earth bunds (as in Kebbe CDA) Leaving crop residues on-site (as in Badau VA)	Sand dune stabilization (WOCAT 53, WOCAT 54)
Soil infertility	Manuring	- Manure should be managed in composting for more efficiency - Adopt the application of produced compost in planting holes/points to reduce losses (rather than broadcasting)	-/-	
	Composting (traditional)	- Improve the composting method and associate planting pits for more efficiency and loss reduction	-/-	Composting associated with planting pits (WOCAT 1)
	Leaving crop residues on site	- Proceed to the ploughing back of the crop residues if available; proceed to composting - Establishment of living fencing around the households and make available the plant residues for composting	Leaving crop residues on-site (as in Badau VA)	
	Intercropping, Mixed-cropping, Crop rotation	- Improve the mix cropping and rotation using appropriate species combination (e.g. mixing the Nitrogen-fixing species with cereals on regular patterns)	-/-	-/-

Soil infertility, soil moisture	Planting pits	- Make sure the pits are not dug at the same places every year to ensure a kind of rotation - Adopting the half-moon/micro-catchment technique could offer more effectiveness and reduce labor inputs	-/-	Composting associated with planting pits (WOCAT 1)
	Ridge ploughing	- Associate tie-ridging to ridges to increase soil moisture conservation while reducing sheet erosion.	-/-	-/-
b. Water harvesting (WH)				
Not mentioned		-/-	-/-	-/-

Table 30. Relevant data from survey for Barangawa community

Some characteristics	Barangawa
Land degradation	Gully erosion, Sheet erosion, Insufficient soil moisture, Water shortage
Main rainfed crops	Millet, Sorghum, Maize, Cowpea, Cassava, Rice
Main irrigated crops	Rice, Wheat, Vegetables
Livestock number in the community	4500
Livestock species	Cattle, Sheep, Goat, Poultry
Multipurpose species on farm	Goyava, Mango, Shea butter, Neem
Average household size	10
Land tenure in rangelands	Government lands
Pasture management	Free access
Land tenure in forests	No
Forest management	No
Communal structure of land governance	No communal structure
Presence of nomadic herders	Occasional
Estimated livestock of nomadic herders	8000
Surface water management	Streams, rivers, ponds
Source of drinking water for human	Open wells, hand pumps, Bore holes
Source of drinking water for livestock	Open wells, hand pumps, Bore holes, Rivers
Water shortage period	May-June
Groundwater table depth (m)	7
Surface water availability	Excess (high runoff)

Surface water quality	Good drinking water
Traditional soil name	Barengo
Modern soil name	Clay soil
Soil depth	Very shallow
Topsoil texture	Coarse
Subsoil texture	Coarse
Topsoil organic matter	Low
Soil structure	Moderate

4.4. MO for communities in Sokoto State

Table 31. MO for Badau, Sokoto State

Issues	Current Practices	Advised improvement	Advised local import	Advised international import
a. Soil and Water Conservation (SWC)				
Gully erosion/Sheet erosion	Planting cover species *(Datura arborea)*	- Need of improving planting patterns and density - Planting can be associated to structural measures plugging the gullies - Gully control at its initiation point is recommended	Planting of cover species and Ron palm (as in Yautabaki VA	Reinforced terraces for stone walls (WOCAT 36) *Jatropha curcas* hedge (WOCAT 30)
	Contour ridges /Contour ploughing	- The ridging/ploughing should be effectively done following the contour lines - Integrate/combine structural (soil bunds/stone bunds) and vegetative measures (Vetiver/Gamba)	-/-	Soil bund & Fanya Juu combined & vegetated (WOCAT 15)
	Placement of sand bags for gully plugging	- Placement of the sand bags should be effective in plugging the gully (covering its width and depth) - Use bags of good quality (resistant materials)	-/-	*Jatropha curcas* hedge (WOCAT 30) Stone wall check dam (WOCAT 31)
	Stone bunds	- Construct the stone bunds using appropriate materials (size of stones) - The size (height and width) of the bunds need to match the site conditions - There is possibility of integrating vegetative measures (planting shrubs/grasses)	Contours bunds (embankments) as in Barangawa VA Earth embankment associated with shrub planting as in Laye (Yobe)	Soil bund & Fanya Juu combined & vegetated (WOCAT 15) Barreiras Vivas de Leucaena (WOCAT 37)
	Combination of measures (Hypomea sp., Vetiver sp. with earth bunds, stone lines)	- Always combine structural (earth bund, stone bunds) and vegetative (grasses) measures for optimal effects and effectiveness - Improve the density of grasses and plant them along the bunds - The vegetative measures can be improved using locally available *Jatropha curcas*	Practice is well done, should be out-scaled to peers. Planting vetiver grasses (like in Baawa VA), integrating the advised improvements	

Wind erosion & deposition	**Crop residues on-site**	- The residues can be more efficiently used through composting on farm - Trees/shrubs plantation can be an effective solution to wind erosion & deposition	Practice is well done, should be out-scaled to peers Planting of cover species and Ron palm (as in Yautabaki VA	*Jatropha curcas* hedge (WOCAT 30)
	Hedge rows made up of shrubs (Aguwa in Haussa)	- Improve the patterns of the living fences - Establishment of community nurseries for shelterbelts/windbreaks - Provide living structure (in rows crossing the farm) or fences (at farm edge) to abate wind velocity and reduce sediment deposition - Identify hotspots (e.g., sand dunes) in the landscape and stabilize them using vegetative measures	Agroforestry associated with earth bunds (as in Kebbe CDA) Leaving crop residues on-site (as in Badau VA)	Sand dune stabilization (WOCAT 53, WOCAT 54) *Jatropha curcas* hedge (WOCAT 30)
Soil infertility	Manuring	- Manure should be managed in composting for more efficiency - Adopt the application of produced compost in planting holes/points to reduce losses (rather than broadcasting)	-/-	Composting associated with planting pits (WOCAT 1)
	Composting (traditional)	- Adopt the application of compost in planting holes/pits to reduce losses	-/-	
	Liming associated with veg and structural measures	-	-/-	
b. Water harvesting (WH)				
Water shortage for livestock drinking	Ponds/ borrow pits	- Establish ponds/dams on suitable sites (cross streams, gullies/runoff ways, lowlands) to increase water harvesting potential - Plant trees and grasses around dams/ponds to reduce insolation and evaporation - Management plans for sustainable use of the ponds/water points; - possibly avoid free livestock access and trampling from all directions	Dams (as in Dogonkuka VA) Animal water drinking point under rehabilitation (such as in Kebbe, Sokoto)	Dams (WOCAT 34) Check dam ponds (WOCAT 33) Runoff / flood water farming (WOCAT 16)

Water shortage for both livestock and domestic use	Bore holes (hand pumps, motorized) Open wells	- Install pumping systems using sustainable sources of energy (solar, wind) to power bore-holes.	Reticulated watering point from solar powered bore hole (such as in Kukawa)	-/-

Table 32. Relevant data from survey for Badau community

Some characteristics	Badau
Land degradation	Gully erosion, Sheet erosion, Soil infertility
Main rainfed crops	Millet, Sorghum, Cowpea, Groundnut, Maize, Onion
Main irrigated crops	Rice, Wheat, Cassava, Vegetables
Livestock number in the community	7000
Livestock species	Cattle, Goats, Sheep, Camel, Poultry
Multipurpose species on farm	Neem, Baobab, Locust beans, Tamarindus
Average household size	8
Land tenure in rangelands	Governmental
Pasture management	Free access
Land tenure in forests	No
Forest management	No
Communal structure of land governance	No structure
Presence of nomadic herders	Seasonal
Estimated livestock of nomadic herders	Not estimated
Surface water management	Ponds
Source of drinking water for human	Open wells, Hand pumps, Bore holes
Source of drinking water for livestock	Open wells, Hand pumps, Bore holes
Water shortage period	No
Groundwater table depth (m)	12
Surface water availability	Good
Surface water quality	Poor drinking water
Traditional soil name	Yashi
Modern soil name	Sandy soil
Soil depth	Shallow
Topsoil texture	Coarse
Subsoil texture	Coarse
Topsoil organic matter	Low

Soil structure	Moderate

Table 33. MO for Kebbe, Sokoto State

Issues	**Current Practices**	**Advised improvement**	**Advised local import**	**Advised international import**
a. Soil and Water Conservation (SWC)				
Gully erosion Sheet erosion	Planting cover species (*Datura arborea*)	- Plant the cover species over the areas under erosion - Preferably integrate plantation by adding structural measures (sand bags, soil/stone bunds) with shrubs (e.g. Jatropha) to plug the gullies and avoid reduction of land size	Planting Vetiver grasses (like in Baawa VA) integrating the advised improvements	Reinforced terraces for stone walls (WOCAT 36) *Jatropha curcas* hedge (WOCAT 30)
	Planting Vetiver grass	- Improve planting patterns and density of grass spots, preferably along soil bunds (which should be established)	Planting Vetiver grasses (like in Baawa VA), integrating the advised improvements	Grass strips (WOCAT 55)
	Planting graminea grass (Kakarkua in Haussa)	- Use this grass for sand dune stabilization - Plant Vetiver/Gamba grasses, preferably on soil/earth bunds (which should be established) to control sheet erosion - Gully plugging sustained with shrubs (e.g. Jatropha) is advised - Gully control at its initiation point is recommended	-/-	
	Planting cover species (*Tchikarami in Haussa*)	- Plant the cover species over the areas under erosion. - Preferably, integrate structural measures (sand bags, soil/stone bunds) with shrubs (e.g. Jatropha) to plug the gullies and avoid reduction of land size	Planting vetiver grasses (like in Baawa VA), integrating the advised improvements	*Jatropha curcas* hedge (WOCAT 30)

	Contour ridges /Contour ploughing	- Plant Vetiver/Gamba grasses in association with soil/earth bunds to control sheet erosion - Associate gully plugging sustained with shrubs (e.g. Jatropha) because contour ploughing alone is not effective for controlling sheet and gully erosion on site - Also implement gully control at its initiation point	Contours bunds (embankments) as in Barangawa VA Planting Vetiver grasses (like in Baawa VA), integrating the advised improvements	Microcatchments and ponds (WOCAT 14) Large semi-circular stone bunds (WOCAT 32)
	Area closure	- Construct wire fencing that can be progressively replaced by vegetative measures such as planting Jatropha curcas.	Assisted fallowing as in Dogonkuka VA	*Jatropha curcas* hedge (WOCAT 30) Area closure for rehabilitation (WOCAT 6)
Wind erosion and deposition	No practice	- Planting graminea grass (Kakarkua in Haussa) is recommended for stabilization of spots of sandy or very loose soils		Grass strips (WOCAT 55)
Sheet erosion/ Soil infertility	**Agroforestry associated with earth bunds**	- Plant *Jatropha curcas* at farm hedge to protect the managed lands - Plant fast growing multipurpose trees (e.g. Moringa)	Practice is well done, should be out-scaled to peers	Parkland Agroforestry System (WOCAT 20)
Soil infertility	Manuring	- Manure management for composting for more efficiency - Adopt the application of compost in planting holes/points to reduce losses	-/-	Composting associated with planting pits (WOCAT 1)
	Composting (traditional)	- Improve the composting method and associate planting pits for more efficiency and loss reduction	-/-	
	Fallowing	- Improve the fallowing by planting leguminous trees or grasses - Appropriate crop rotation can be adopted	Assisted fallowing as in Dogonkuka VA	Rehabilitation of degraded lands (WOCAT 13) Area closure for rehabilitation (WOCAT 6)
	Intercropping	- Improve the cropping and rotation using appropriate species combination (e.g. mixing the Nitrogen-fixing species with cereals on regular patterns)	-/-	-/-
	Crop rotation	- Improve the rotation using appropriate crops (e.g. mixing the Nitrogen-fixing species with cereals) to control nutrient uptake and avoid salinity	-/-	

b. Water harvesting (WH)				
Water shortage for both animal & domestic use	**Ponds/borrow pits (under rehabilitation)**	- Rehabilitate/enlarge the pond by increasing its depth to store water year-round - Improve the diversion channel towards the pond catchment under rehabilitation to increase water harvesting potential - Plant trees and grasses around dams/ponds to reduce insolation and evaporation - Possibly avoid free livestock access and trampling from all directions - Increase the number of similar interventions on suitable sites throughout the landscapes - Provide management plans for sustainable use of the ponds/water points	Dams (like in Dogonkuka VA) Good rehabilitation plan (to be outscaled).	Dams (WOCAT 34) Check dam ponds (WOCAT 33) Runoff / flood water farming (WOCAT 16)
Water shortage for both livestock and domestic use	Bore holes (hand pumps, motorized) Open wells	- Install pumping systems using sustainable sources of energy (solar, wind) to power bore-holes.	Reticulated watering point from solar powered bore hole (such as in Kukawa)	-/-

Table 34. Relevant data from survey for Kebbe community

Some characteristics	Kebbe
Land degradation	Gully erosion, Sheet erosion, Wind erosion & deposition
Main rainfed crops	Millet, Groundnut, Cowpea, Maize, Sorghum, Rice
Main irrigated crops	Rice, Potato, Maize, Vegetables
Livestock number in the community	Not estimated
Livestock species	Cattle, Sheep, Goat, Poultry
Multipurpose species on farm	Cashew, Mango, Goyava, Locust beans, Vitex, Moringa
Average household size	14
Land tenure in rangelands	Governmental
Pasture management	Both Free access + Restricted
Land tenure in forests	Governmental
Forest management	Restricted
Communal structure of land governance	No structure at community level

Presence of nomadic herders	Regular
Estimated livestock of nomadic herders	10000
Surface water management	Ponds, dams
Source of drinking water for human	Open wells, Hand pumps, Bore holes
Source of drinking water for livestock	Open wells, Hand pumps, Bore holes
Water shortage period	February-June
Groundwater table depth (m)	24
Surface water availability	Good
Surface water quality	Poor drinking water
Traditional soil name	Rarayi
Modern soil name	Sandy loam
Soil depth	Shallow
Topsoil texture	Coarse
Subsoil texture	Coarse
Topsoil organic matter	Medium
Soil structure	Moderate

4.5. MO for communities in Zamfara State

Table 35. MO for Yautabaki, Zamfara State

Issues	Current Practices	Advised improvement	Advised local import	Advised international import
a. Soil and Water Conservation (SWC)				
Gully erosion, sheet erosion	**Combination of planting cover species (*Hypomea sp.*) and ron palm**	- Increase the density and the number of planted rows to effectively plug the gully - Address the gully at its initiation point by stabilizing the soil	Practice is well done, should be out-scaled to peers Planting vetiver grasses (like in Baawa VA), integrating the advised improvements	Soil bund & Fanya Juu combined & vegetated (WOCAT 15) Barreiras Vivas de Leucaena (WOCAT 37)
	Combination of fencing and planting cover grasses (*Hypomea sp.*)	- Provide solid living structure by planting trees/shrubs at the gully banks to stabilize the gully - Associate gully plugging measures (stones, sand bags as check points) - Address the gully at its initiation point by stabilizing the soil	-/-	Barreiras Vivas de Leucaena (WOCAT 37) Jatropha curcas hedge (WOCAT 30)
	Planting Vetiver grass	- Associate the grass planting with earth bunds for more effectiveness	Planting Vetiver grasses (like in Baawa VA), integrating the advised improvements	Grass strips (WOCAT 55)
	Planting of *Datura arborea* as cover plant	- Plant the cover species over the areas under erosion. - Preferably, integrate structural measures (sand bags, soil/stone bunds) with shrubs (e.g. Jatropha) to plug the gullies and avoid reduction of land size	Planting Vetiver grasses (like in Baawa VA), integrating the advised improvements	Reinforced terraces for stone walls (WOCAT 36) *Jatropha curcas* hedge (WOCAT 30)
	Placement of sand bags	- Placement of the sand bags should be effective in plugging the gully (covering its width and depth) - Use bags of good quality (resistant materials)	Contours bunds (embankments) as in Barangawa VA	*Jatropha curcas* hedge (WOCAT 30) Stone wall check dam (WOCAT 31)
	Construction of stone bunds	- Undertake a general maintenance of the bunds (as width and height)	Contours bunds (embankments) as in Barangawa VA	Soil bund & Fanya Juu combined & vegetated (WOCAT 15)

		- Establish, or restore, the vegetative measures and increase planting of trees/shrubs (along the bunds		Dawa-Chea Traditional Checkdam (WOCAT 7)
Sheet erosion	Ridge ploughing	- Make sure ridging is done along contour lines - Associate tie-ridging to contour ridges to reduce runoff in ridges.	-/-	Soil bund & Fanya Juu combined & vegetated (WOCAT 15)
Wind erosion & deposition	**Combination of planting cover species (*Hypomea sp.*) and ron palm**	- Provide a more solid living structure by increasing the number and length of planted rows to abate wind velocity and reduce sediment deposition - Identify hot spots (e.g., sand dunes) in the landscape and stabilize them using vegetative measures (tree planting)	Planting of cover species and Ron palm (as in Yautabaki VA) Agroforestry associated with earth bunds (as in Kebbe CDA) Leaving crop residues on-site (as in Badau VA)	Sand dune stabilization (WOCAT 53, WOCAT 54)
Soil infertility	Manuring	- Manure management for composting for more efficiency - Adopt the application of compost in planting holes/points to reduce losses	-/-	
	Composting	- Improve the composting method and associate planting pits for more efficiency and loss reduction	-/-	Composting associated with planting pits (WOCAT 1)
	Leaving crop residues on-site	- Proceed to the ploughing back of the crop residues if available; proceed to composting - Establishment of living fencing around the households and make available the plant residues for composting	Leaving crop residues on-site (as in Badau VA)	
	Mixed cropping, relay cropping, crop rotation	- Improve the cropping and rotation using appropriate species combination (e.g. mixing the Nitrogen-fixing species with cereals on regular patterns)	-/-	-/-
Soil infertility and soil moisture	Ridge ploughing	- Associate tie-ridging to contour ridges to improve soil moisture conservation and increase soil organic matter while reducing sheet erosion	-/-	Soil bund & Fanya Juu combined & vegetated (WOCAT 15)
b. Water harvesting (WH)				

Water shortage for both animal and domestic purposes	Ponds	- Rehabilitate/enlarge ponds to store water year-round - Establish ponds/dams on suitable sites (cross streams, gullies/runoff ways, lowlands) to increase water harvesting potential - Plant trees and grasses around dams/ponds to reduce insolation and evaporation - Possibly avoid free livestock access and trampling from all directions	Dams (like in Dogonkuka VA) Animal water drinking point under rehabilitation (such as in Kebbe, Sokoto)	Dams (WOCAT 34) Check dam ponds (WOCAT 33) Runoff / flood water farming (WOCAT 16)
Water shortage for human consumption	Open wells Bore holes (solar-powered and hand power)	- Install pumping systems using sustainable sources of energy (solar, wind) to power bore-holes.	Reticulated watering point from solar powered bore hole (such as in Kukawa)	-/-

Table 36. Relevant data from survey for Yautabaki community

Some characteristics	**Yautabaki**
Land degradation	Gully erosion, Animal drinking points, Wind erosion, Shortage of drinking water, Soil infertility
Main rainfed crops	Maize, Sorghum, Groundnut, Cowpea, Millet, Sesame
Main irrigated crops	Onion, Garden eggs, Watermelon, Tomatoes, Sweet potatoes, Pepper, Sugarcane
Livestock number in the community	Not estimated
Livestock species	Cattle, Goat, Sheep, Camels, Poultry
Multipurpose species on farm	Mango, Baobab, Locust beans, Acacia, Shea tree, Neem
Average household size	12
Land tenure in rangelands	Communal
Pasture management	Common access
Land tenure in forests	No
Forest management	No
Communal structure of land governance	Traditional community regulation schemes
Presence of nomadic herders	Yes, occasional
Estimated livestock of nomadic herders	Not estimated
Surface water management	Rivers/streams, Borrow pits
Source of drinking water for human	Rivers, Bore holes, Hand pumps
Source of drinking water for animal	Rivers, Borrow pits

Water shortage period	March-May
Groundwater table depth (m)	74
Surface water availability	Good
Surface water quality	Dominantly poor drinking water
Traditional soil name	Jambally, Jigawu
Modern soil name	Ferruginous soil, sandy loam
Soil depth	Very shallow to shallow
Topsoil texture	Coarse
Subsoil texture	Coarse
Topsoil organic matter	Low to medium
Soil structure	Weak to moderate

Table 37. MO for Gora Namaye, Zamfara State

Issues	**Current Practices**	**Advised improvement**	**Advised local import**	**Advised international import**
a. Soil and Water Conservation (SWC)				
Gully erosion	Cover species (*Hypomea sp, Datura arborea)*	- Plug gullies using stone/sand bags associated with shrub/tree planting - Address gully at its initiation point through water diversion channel sustained with planted grasses (Jatropha, Tchikariami)	Planting vetiver grasses (like in Baawa VA), integrating the advised improvements	Barreiras Vivas de Leucaena (WOCAT 37) Soil bund & Fanya Juu combined & vegetated (WOCAT 15)
	Combination of sand bags and stone bunds	- Sustain the practice using material of good quality (resistant bags) - Integrate vegetative measures (shrubs/tree like *Jatropha curcas*, Tchikarami) to sustain the structure. - Increase the size of the structures and their number across the main gully and runoff flow direction	-/-	Jatropha curcas hedge (WOCAT 30) Soil bund & Fanya Juu combined & vegetated (WOCAT 15)
Sheet erosion	Contour ploughing	- Combine tie ridging and contour ridging associated with earth bunds consolidated with grasses (Vetiver or Gamba) for more effectiveness	-/-	Soil bund & Fanya Juu combined & vegetated (WOCAT 15)
	Planting Gamba grass	- Plant grasses/shrubs associated to earth/soil bunds	Planting vetiver or Gamba (like in Baawa VA), integrating the advised improvements	Grass strips (WOCAT 55)

	(*Andropogon gayanus*)			
Wind erosion	Planting of cover species (*Hypomea sp.*)	- Provide a more solid living structure by increasing tree planting (neem, Leucaena, Moringa, Locust beans, Shea butter, Mango, etc.) and shrubs (Jatropha) to abate wind velocity and reduce sediment deposition	Planting of cover species and Ron palm (as in Yautabaki VA) Agroforestry associated with earth bunds (as in Kebbe CDA) Leaving crop residues on-site (as in Badau VA)	
	Planting of *Jatropha curcas*	- Provide a more solid living structure by increasing tree planting (neem, Leucaena, Moringa, Locust beans, Shea butter, Mango, etc.) and shrubs (Jatropha) to abate wind velocity and reduce sediment deposition	-/-	*Jatropha curcas* hedge (WOCAT 30)
Soil infertility	Combination of crop residues and husks of locust beans fruits	- Proceed to composting to increase effectiveness of the measure, since control of weed is expected to be achieved by increasing soil fertility - Planting indigenous leguminous trees (agroforestry systems) on cultivated lands (green manuring)	-/-	Composting associated with planting pits (WOCAT 1)
	Combination of manuring, mulching and ridge ploughing	- Proceed to composting - Integrate indigenous leguminous species (agroforestry systems) to cultivated lands	Practice is well done, should be out-scaled to peers	Composting associated with planting pits (WOCAT 1) Soil bund & Fanya Juu combined & vegetated (WOCAT 15)
	Manuring	- Manure management for composting for more efficiency - Adopt the application of compost in planting holes/points to reduce losses	-/-	Composting associated with planting pits (WOCAT 1)
	Composting	- Improve the composting method and associate planting pits for more efficiency and loss reduction	-/-	
	Mixed cropping, relay cropping, crop rotation	- Improve the cropping and rotation using appropriate species combination (e.g. mixing the Nitrogen-fixing species with cereals on regular patterns)	-/-	-/-

Soil infertility and soil moisture	Ridge ploughing	- Associate tie-ridging to contour ridges to improve soil moisture conservation and increase soil organic matter while reducing sheet erosion	-/-	Soil bund & Fanya Juu combined & vegetated (WOCAT 15)
Waterlogging	Planting of adapted crops (rice, vegetables)	- Establish water diversion and drainage systems (if possible based on site conditions)	-/-	-/-
b. Water harvesting (WH)				
Water shortage for both livestock and human consumption	Ponds	- Rehabilitate/enlarge existing ponds to store water year-round - Improve trees and grasses cover around dams/ponds to reduce insolation and evaporation, stabilize the water point and reduce the siltation - Possibly avoid free livestock access and trampling from all directions	Dams (like in Dogonkuka VA) Animal water drinking point under rehabilitation (such as in Kebbe, Sokoto)	Dams (WOCAT 34) Check dam ponds (WOCAT 33) Runoff / flood water farming (WOCAT 16)
	Open wells Bore holes (solar-powered and hand power)	- Install pumping systems using sustainable sources of energy (solar, wind) to power bore-holes.	Reticulated watering point from solar powered bore hole (such as in Kukawa)	-/-

Table 38. Relevant data from survey for Gora Namaye community

Some characteristics	Gora Namaye
Land degradation	Gully erosion, Sheet erosion, Soil infertility, Waterlogging, Water shortage for animal drinking
Main rainfed crops	Sorghum, Millet, Maize, Cowpea
Main irrigated crops	Rice, Vegetables
Livestock number in the community	Not estimated
Livestock species	Sheep, Cow, Goat, Poultry
Multipurpose species on farm	Locust beans, Mango, Baobab
Average household size	10
Land tenure in rangelands	No
Pasture management	No
Land tenure in forests	Governmental
Forest management	Free access
Communal structure of land governance	Forestry guard committee

Presence of nomadic herders	Regular
Estimated livestock of nomadic herders	Not estimated
Surface water management	Irrigated channels, streams
Source of drinking water for human	Hand pumps, Hand wells, Bore holes
Source of drinking water for animal	Hand pumps, Hand wells, Bore holes
Water shortage period	April-May
Groundwater table depth (m)	15
Surface water availability	Good
Surface water quality	Dominantly poor drinking water
Traditional soil name	Jigawa, Damba
Modern soil name	Sandy loam, Clay loam
Soil depth	Shallow
Topsoil texture	Medium to coarse
Subsoil texture	Medium to coarse
Topsoil organic matter	Low
Soil structure	Moderate to strong

4.6. MO for communities in Yobe State

Table 39. MO for Laye community, Yobe State

Issues	Current Practices	Advised improvement	Advised local import	Advised international import
a. Soil and Water Conservation (SWC)				
Gully erosion, sheet erosion	Contour ploughing	- Make sure ridging follows the contour - Associate with earth bunds consolidated with grasses (Vetiver or Gamba) for more effectiveness, and combine tie ridging and contour ridging	-/-	Soil bund & Fanya Juu combined & vegetated (WOCAT 15)
	Earth embankments associated with shrub planting	- Provide regular maintenance of the bunds (as width and height) - Enhance vegetative measures to sustain the embankment - Align them more systematically with embankment and increase their density to consolidate the structures	Practice is well done, should be out-scaled to peers, integrating advised improvements	Soil bund & Fanya Juu combined & vegetated (WOCAT 15) Reinforced terraces for stone walls (WOCAT 36)
	Tree planting/Woodlots	- Plant fast grow trees having good root systems - Convert waste lands due to erosion into community woodlots (benefits: restore lands and provide firewood)	-/-	Rehabilitation of degraded lands (WOCAT 13) *Jatropha curcas* hedge (WOCAT 30)
Soil infertility	Manuring	- Manure management for composting for more efficiency - Adopt the application of compost in planting holes/points to reduce losses	-/-	Composting associated with planting pits (WOCAT 1)
	Composting	- Adopt improved compost making to maximize the recycling of organic matter from wastes	-/-	
	Crop rotation	- Improve the mix cropping and rotation using appropriate species combination (e.g. mixing the Nitrogen-fixing species with cereals on regular patterns)	-/-	
	Intercropping	- Same recommendation as for crop rotation	-/-	-/-

	Agroforestry	- Associate multipurpose tree species for improving organic matter inputs to soil	Agroforestry in farmland (as in Kebbe)	Parkland Agroforestry System (WOCAT 20)
Lack of fiewood	Planting trees/woodlots	- Establishment of community nursery - Encourage individual and community woodlots establishment	-/-	Afforestation and Hillside Terracing (WOCAT 40) Afforestation (WOCAT 50)
b. Water harvesting (WH)				
Not mentioned	-/-	-/-	-/-	-/-

Table 40. Relevant data from survey for Laye community

Some characteristics	**Laye**
Land degradation	Gully erosion, Sheet erosion, Soil infertility
Main rainfed crops	Millet, Groundnut, Sorghum, Bambara nut, Cowpea, Sesame
Main irrigated crops	No
Livestock number in the community	20000
Livestock species	Cow, Goat, Sheep, Donkey,Poultry
Multipurpose species on farm	Neem, Mango, Tamarin, Moringa, Baobab
Average household size	18
Land tenure in rangelands	No
Pasture management	No
Land tenure in forests	No
Forest management	No
Communal structure of land governance	Communal lands governing board
Presence of nomadic herders	Occasional
Estimated livestock of nomadic herders	4000
Surface water management	Ponds/borrow pits
Source of drinking water for human	Wells, bore holes
Source of drinking water for animal	Wells, bore holes
Water shortage period	March-May
Groundwater table depth (m)	48
Surface water availability	Excess (high rainfall)
Surface water quality	Poor drinking water
Traditional soil name	Yaya or Illi
Modern soil name	Sandy to sandy loam soil

Soil depth	Shallow
Topsoil texture	Coarse
Subsoil texture	Coarse
Topsoil organic matter	Low
Soil structure	Weak

Table 41. MO for Dogonkuka community, Yobe State

Issues	Current Practices	Advised improvement	Advised local import	Advised international import
a. Soil and Water Conservation (SWC)				
Gully erosion, sheet erosion	Contour ploughing	- Associate with earth bunds consolidated with grasses (Vetiver or Gamba) for more effectiveness - Combine tie ridging and contour ridging for enhanced runoff control	Contours bunds (embankments) as in Barangawa VA	Soil bund & Fanya Juu combined & vegetated (WOCAT 15)
	Sand bags	- Placement of the sand bags should be effective in plugging the gully (covering its width and depth) - Use bags of good quality (resistant materials)	-/-	*Jatropha curcas* hedge (WOCAT 30) Stone wall check dam (WOCAT 31)
	Planting Gamba grass, Datura a., with contour ploughing	- Associate the grass planting with earth bunds for more effectiveness - Improve the grass density to increase effectiveness	Practice is well-done, scale out to peers Planting Vetiver grasses (like in Baawa VA), integrating the advised improvements	Grass strips (WOCAT 55)
	Tree planting/Woodlots/orchards	- Planting fast grow trees having good root systems - Convert waste lands due to erosion into community woodlots (benefits: restore lands and provide firewood)	Practice is well-done, scale out to peers	Rehabilitation of degraded lands (WOCAT 13) - *Jatropha curcas* hedge (WOCAT 30)
	Assisted fallowing on previously ploughed lands	- Plant cover crops (e.g. Mucuna or similar leguminous) on plots set to fallow - Minimize the risks of illegal grazing using fencing	Practice is well-done, scale out to peers	Assisted Natural Regeneration of Degraded Land (WOCAT 21)

Soil infertility	Manuring	- Manure management for composting for more efficiency - Adopt the application of compost in planting holes/points to reduce losses	-/-	
	Composting	- Adopt improved compost making to maximize the recycling of organic matter from wastes	-/-	Composting associated with planting pits (WOCAT 1)
	Crop rotation	- Improve the mix cropping and rotation using appropriate species combination (e.g. mixing the Nitrogen-fixing species with cereals on regular patterns)	-/-	
	Agroforestry	- Associate multipurpose tree species for improving organic matter inputs to soil	Agroforestry in farmland (as in Kebbe)	Parkland Agroforestry System (WOCAT 20)
Lack of firewood	Planting trees/woodlots	- Establishment of community nursery - Encourage individual and community woodlots establishment	-/-	Afforestation and Hillside Terracing (WOCAT 40) Afforestation (WOCAT 50)
b. Water harvesting (WH)				
Water shortage for both animal drinking	**Dams**	- Possibly avoid free livestock access and trampling from all directions - Avoid the damping of wastes and other solid materials in the dam	Practice is well done, should be out-scaled to peers	Dams (WOCAT 34) Check dam ponds (WOCAT 33) Runoff / flood water farming (WOCAT 16)
Water shortage for human consumption	Open wells Bore holes (solar-powered and hand power)	- Install pumping systems using sustainable sources of energy (solar, wind) to power bore-holes.	Reticulated watering point from solar powered bore hole (such as in Kukawa)	-/-

Table 42. Relevant data from survey for Dogon Kuka community

Some characteristics	Dogon Kuka
Land degradation	Gully erosion, Sheet erosion, Soil infertility, Water shortage for animal drinking
Main rainfed crops	Millet, Sorghum, Groundnut, Cowpea, Sesame, Bambaranut
Main irrigated crops	Watermelon, Sweet melon, Sweet potato, Tomatoes
Livestock number in the community	18400
Livestock species	Cow, Sheep, Goat, Poultry, Horse, Donkey
Multipurpose species on farm	Cashew, Mango, Moringa, Neem, Goyava, Baobab

Average household size	15
Land tenure in rangelands	Communal
Pasture management	Free access
Land tenure in forests	Government Forest reserve
Forest management	Law enforced
Communal structure of land governance	Civil vigilantes
Presence of nomadic herders	Occasional
Estimated livestock of nomadic herders	100000
Surface water management	Dam, Small ponds
Source of drinking water for human	Wells, Bore holes
Source of drinking water for livestock	Wells, Bore holes
Water shortage period	April-May
Groundwater table depth (m)	30
Surface water availability	Excess (high runoff)
Surface water quality	Poor drinking water
Traditional soil name	Aisi
Modern soil name	Sandy soil
Soil depth	Shallow
Topsoil texture	Coarse
Subsoil texture	Coarse
Topsoil organic matter	Low to medium
Soil structure	Moderate to strong

Table 43. MO for Jimbam community, Yobe State

Issues	Current Practices	Advised improvement	Advised local import	Advised international import
a. Soil and Water Conservation (SWC)				
Gully erosion, sheet erosion	Tree planting/Wood lots	- Planting fast grow trees having good root systems - Convert waste lands due to erosion into community woodlots (benefits: restore lands and provide firewood)	-/-	- Rehabilitation of degraded lands (WOCAT 13) - *Jatropha curcas* hedge (WOCAT 30)

	Sand bags	- Placement of the sand bags should be effective in plugging the gully (covering its width and depth) - Use bags of good quality (resistant materials) - Associate contour bunds stabilized with vegetative measures to control sheet erosion and gullies at initiation points	Contours bunds (embankments) as in Barangawa VA	- *Jatropha curcas* hedge (WOCAT 30) Stone wall check dam (WOCAT 31)
	Abandonment for natural regeneration	- Assist the natural regeneration by planting trees, plugging the gully and avoiding animal encroachment on the lands	Practice is well done, should be out-scaled to peers, integrating advised improvements	
Soil infertility	Manuring	- Manure management for composting for more efficiency - Adopt the application of compost in planting holes/points to reduce losses	-/-	Composting associated with planting pits (WOCAT 1)
b. Water harvesting (WH)				
Water shortage for animal drinking	Ponds	- Rehabilitate/enlarge ponds to store water year-round - Establish ponds/dams on suitable sites (cross streams, gullies/runoff ways, lowlands) to increase water harvesting potential - Plant trees and grasses around dams/ponds to reduce insolation and evaporation - Possibly avoid free livestock access and trampling from all directions	Dams (like in Dogonkuka VA)	Dams (WOCAT 34) Check dam ponds (WOCAT 33) Runoff / flood water farming (WOCAT 16)
Water shortage for both animal & domestic use	Individual containers	- Improve the capacity of the containers to store more water year-round - Introduce community-based WH systems	Reticulated watering point from solar powered bore hole (such as in Kukawa)	-/-

Table 44. Relevant data from survey for Jimbam community

Some characteristics	**Jimbam**
Land degradation	Gully erosion, Sheet erosion, Soil infertility, Water shortage for animal drinking, Lack of grazing lands
Main rainfed crops	Millet, Sorghum, Sesame, Cowpea, Groundnut, Rice

Main irrigated crops	Rice, Wheat, Vegetables, Cassava
Livestock number in the community	111150
Livestock species	Cattle, Sheep, Goat, Poultry, Donkey, Horse, Camel
Multipurpose species on farm	*Senna siamea, Balanites aegyptiaca, Prosopis africana, Azadirachta indica, Adansonia digitata*
Average household size	10
Land tenure in rangelands	No
Pasture management	No
Land tenure in forests	No
Forest management	No
Communal structure of land governance	Staff in local government
Presence of nomadic herders	Occasional
Estimated livestock of nomadic herders	100000
Surface water management	Ponds, Oasis, Rivers
Source of drinking water for human	Bore holes
Source of drinking water for animal	Dams, Ponds
Water shortage period	May-June
Groundwater table depth (m)	15
Surface water availability	Good
Surface water quality	Unusable
Traditional soil name	Warawara
Modern soil name	Loamy soil
Soil depth	Shallow
Topsoil texture	Medium
Subsoil texture	Medium
Topsoil organic matter	Medium
Soil structure	Strong

4.7. Summary of model practices across the States

The table below summarizes the practices that were identified as relatively well done and recommended for out-scaling through peer to peer learning and adoption.

Table 45. Summary of observed model practices across the survey sites

Types of practices	**Practice**	**Model case observed in**
SWC and soil moisture	Contours bunds (embankments)	Barangawa
	Earth embankments associated with shrub planting	Laye
	Sand bagging, stone bunds, and shrub planting	Kofa, Katsina
	Planting cover species and Ron palm	Yautabaki
	Leaving crop residues on-site	Badau
	Planting vetiver grasses	Baawa
	Association of Gamba grass and fallowing	Dagwaje
	Planting Gamba grass, Datura arborea, in association with contour ploughing	Dogonkuka, Yobe
	Planting grasses associated with shrubs	Gana-Kaya, Jigawa
	Association of crop residues with cover plants (e.g. Coloquinte)	Kukawa, Jigawa
	Combination of manuring, mulching, and ridge ploughing	Goran, Zamfara
	Combination of measures (*Datura arbora*, *Vetivera sp*. with earth bunds, stone lines, and liming)	Badau, Kebbi
	Woodlots	Gana-Kaya, Jigawa
	Tree planting, woodlots, orchards	Dogonkuka, Yobe
	Nursery for tree planting	Kukawa
	Agroforestry associated with earth bunds	Kebbe
	Assisted fallowing	Dogonkuka
	Abandonment for natural regeneration	Jimbam, Yobe
Water harvesting and management	Animal water drinking point under rehabilitation	Kebbe, Sokoto
	Reticulated watering point from solar powered bore hole	Kukawa
	Dams	Dogonkuka

5. Challenges and factors of success in SLM adoption

Some issues were observed that constitute obstacles to the adoption of SLM practices, and some factors of success were identified, as schematically summarized below by type of measure (order is not by importance).

5.1. Challenges to SWC adoption

- Destruction of vegetative and structural measures by animals
- Droughts and heavy rainfalls affect seedlings
- High runoff carrying away seeds, seedlings
- Difficult to plant and maintain some species: e.g. *B. aethiopum*
- Competition of planted species with native species/grasses
- Steep slope and loose soil types (very sandy soils) make intervention difficult, less effective
- Lack of technical support for implementation
- Need to secure maintenance for permanent structures
- Labor and investment -demanding
- Capital demanding: very costly in some cases

5.2. Factors of success

- Availability of input material: freely available grasses and residues
- Commitment and self-devotion of farmers
- Positive impacts: effectiveness of implementation with positive impacts such as increased crop production,
- Provision of manure by livestock at individual household level (livestock integration)
- Proximity of farm house, enabling permanent watch over
- SLM adopted at small scale
- Traditional practices with experience-based implementation, requiring less inputs

5.3. Factors for enhancing SLM adoption

- Financial capital availability: cost of maintenance (e.g. fencing)

- Collaborative work: collective implementation over large community land/catchments (e.g. for establishing communal water harvesting systems)
- Combination of multiple SWC measures
- Labor and time: availability of labor to expand adoption
- Technical support: support for more effective and larger scale adoption

6. Multi-scale, holistic interventions

To build resilient communities and landscapes in the CASP sites, multi-scale and holistic interventions are necessary to address the diverse land degradation and societal challenges (energy lack, water shortage, etc.) and to avoid social conflicts related to land degradation in future.

6.1. Addressing wind erosion

The unique viable way to tackle wind erosion is to promote actions aimed at reducing wind velocity over fields (to be integrated with actions on soil structure/erodibility).

Wind erosion needs to be tackled with a more holistic and multi-scale approach than currently done. Although tree planting is done spontaneously and tree density in the landscape is often acceptable, improvements are recommended at:

i) farm level: more systematic planting along the hedges exposed to main winds, alternate tree species with either fruit/fodder value and green manure value (e.g., Locust beans tree), and use species (e.g., Neem tree) that can be coppiced/pruned to develop a dense canopy near the ground

ii) community level: design of community wind breaks with appropriate tree assemblage, and develop a community nursery to provide seedlings

iii) landscape level: understand landscape patterns for appropriate allocation of measures in space. Large sand dune fields are present where the dune ridges are being cropped and have poor vegetation cover, with high risk of being destabilized and eroded (by either water and/or wind depending on degree of cementation). Identify dune ridges as hotspots for intervention. Stabilize dunes to avoid creation of wasteland and to mitigate risk of sediment deposition on the neighboring fields. Agroforestry approaches for highly vulnerable areas, ridges can become natural wind breaks.

6.2. Addressing water erosion (gully, sheet and surface runoff)

The sustainable approach to address water erosion is to promote actions aiming at managing water behavior (runoff amount, velocity, and paths) over fields. The adoption of conservation/mitigation practices should also consider the topography, soil types, land use, etc. Efforts should target the erosion initiation points (prevent surface runoff, improve soil surface cover, abate water velocity, etc.), the sediment transport and deposition sites, at:

i) Farm level: target all sites exposed to water erosion (gully, sheet, or runoff). The identification of all potential sources of water erosion on farm is necessary to develop appropriate conservative measures based on site specific conditions. Furthermore, the improvement of water infiltration through the prevention of surface crust formation, the protection of soil surface, and the adoption of good management practices (through water harvest techniques).

ii) Community level, the collective adoption of soil conservation at farm level could help to holistically address water erosion issues. This requires the identification of the erosion hotspots and the promotion of community actions to address the problems through collaborative works among the community members and with the neighbor communities.

iii) Landscape level, there is a need to promote collaboration and communication among different communities to identify hotspots of water erosion and address them with appropriate interventions.

6.3. Addressing soil infertility and soil moisture issues

In general, improving the level of organic matter in soils using manure, crop residues, plant residue inputs, etc. would improve soil structure, soil water retention, and nutrient recycling capacities of the soil.

i) Farm level: more efforts are needed to promote on-site nutrient cycling (through leaving crop residues on-site, appropriate associations of crops, crop rotation, fallowing, etc.) and assisted fertility maintenance (organic matter import through manure import, cover crops during off-season, agroforestry, etc.). The crop types should be aligned with the soil types.

ii) Community level: since the land area per capita is reducing over time, it is important to adopt the specific recommendation at farm household level to increase yield, reduce pressures on lands, and favor the fallow and sustainable agricultural landscapes. Livestock integration can also be enhanced if community members collaborate. Additional efforts should target the reduction of soil pollution by plastic garbage and other chemical substances that may destroy soil fauna, reduce water infiltration and consequently destabilize soil structure.

iii) Landscape level: actions aiming at reversing soil infertility are the result of small scale efforts (farm and community levels). The restoration of soil fertility may also result from the efforts aiming at addressing soil erosion (wind and water) and reducing the degradation factors (such as uncontrolled grazing on croplands, bushfires, etc.). Promoting the adoption of agroforestry practices in combination with the enforcement of legislation (e.g. avoid free grazing on croplands and respect cattle routes) at landscape level should be at focus to reduce supplementary factors of soil fertility loss.

6.4. Addressing water shortage

In the CASP sites, water shortage occurs during the dry season, especially due to the lowering of the water table, and to the drying up of surface water points. In this regard, appropriate efforts are needed at different levels to address the challenge:

i) At household level; the issues of water shortage are twofold: domestic usage and animal consumption, very acute in most of the communities during the dry season. In this sense, efforts should be done to improve water storage infrastructures such as tanks (large containers), open dug wells and/or boreholes powered by solar energy. These actions could help in storing water during rainy season for usage in time of scarcity for both animal and human needs.

ii) Community level; construction/improvement and maintenance of communal infrastructures for water supply such as community dams, community water pumps, and solar powered boreholes. In addition, the management of natural water points (ponds, rivers) could improve water availability for multiple usages (irrigation, livestock consumption, human needs).

iii) Landscape level: the identification of potential sites for constructing larger water storage structures (e.g., dams), and/or the improvement of the collective management of natural sites could help in securing early shortage of water and increasing water availability throughout the season. In addition, the management of water points for animal rearing and transhumant could reduce conflicts related to water.

6.5. Supporting sustainable production of fodder/forage resources

The promotion of the sustainable production of fodder and forage resources is critical to reducing the impacts of grazing on land degradation. Great part of the economy in the CASP sites is based on livestock. In this regard, the development of forage production sites would help to successful combat land degradation and lack of forage resources.

i) household level: each farm household (farm size allowing) should dedicate a piece of land to fodder production. As an alternative, it is possible to plant forage species on fallowed lands, waste lands, etc. Crop residues could also be partly used to feed animals.

ii) Community level: it is possible to create community pastures on the communal lands. The identification of appropriate sites and the promotion of good management practices are keys to sustainably improve good quality fodder availability. Commercial fodder production should be promoted, especially during the off-season, as a component of the agribusiness and sustainable rural transformation.

iii) At landscape level, the participatory management of common rangelands and the identification of natural grazing areas are key to sustain fodder availability at landscape level. In combination with the efforts at household and community levels targeting the wind and water erosion, energy issues, soil fertility and water shortage management, the landscape level rangelands and forage resource management are possible throughout the CASP sites.

6.6. Addressing wood energy challenges

While the State governments are promoting clean energy (gaz, biofuel, electricity, etc.) for supporting rural transformation in the CASP sites, there should be efforts aiming at meeting farm energy needs for multiple purposes like cooking, heating, lighting, etc.:

ii) At the community level (and household, when applicable), actions should be promoted to develop woodlots to meet the energy consumption and commercial needs. This will reduce the reliance of the individual households on the wild landscapes, common lands, and protected areas. These actions could lead to the development of either private or cooperative forestry lands, generating income;

iii) At the landscape level, efforts to co-manage and develop forestry on common lands should target long term benefits, including wind break and dust storm mitigation, climate regulation, fodder production, income generation, etc.

7. Conclusions and recommendations

The aim of this report was to summarize the results of the work conducted in the savannah belt of Nigeria to analyze the effectiveness of the current SWC/WH techniques in 16 targeted communities located in 6 States and to identify sets of context-specific improved options.
In the different communities, a diversity of options exists. They are adopted by land users to address land degradation, particularly soil erosion (sheet and gullies), wind erosion and deposition, soil infertility, soil moisture shortage, lack of surface water for animal and human consumption, lack of fuelwood. The results showed that the existing SWC and WH techniques would become much more effective if recommended improvements were implemented, through the engagement of the communities and through some innovations.

However, several challenges and constraints may hinder the successful implementation of the different SWC/WH measures. Factors of success include increasing financial capital availability and accessibility to credit, encouraging collaborative initiatives in the communities, providing technical support to communities and engage them into large scale adoption. In addition to the above, building sustainable landscapes and communities in the Savannah belt of Nigeria require great focus on the following aspects: (i) promoting sustainable agricultural intensification, given land resource scarcity; (ii) promoting continuous adoption of SLM practices at scale; (iii) promoting community forestry and rangeland development; (iv) creating and diversifying income generation activities (agribusiness); (v) promoting indigenous knowledge generation and innovation through participation and collaboration of land users; (vi) undertake capacity building at the community level to promote rural transformation processes that preserve the natural resource base; (vii) enabling mechanisms for the appropriation (ownership) of projects/program outcomes; (viii) promoting access to information and gender consideration in matter of SLM adoption.

ANNEX 1. Measures adopted in similar agro-ecological contexts

Note: The codes are hyperlinked to the WOCAT website for full information on the technologies.

Code	SWC Technologies	Brief description	Country
WOCAT1	Composting associated with planting pits	Compost production, and its application in planting pits (zai) by farmers on fields near their homes. Compost is produced in shallow pits, approximately 20 cm deep and 1.5 m by 3 m wide. During November and December layers of chopped crop residues, animal dung and ash are heaped, as they become available, up to 1.5 m high and watered. The pile is covered with straw and left to heat up and decompose. After around 15-20 days the compost is turned over into a second pile and watered again. This is repeated up to three times – as long as water is available. Compost heaps are usually located close to the homestead. Alternatively, compost can be produced in pits which are up to 1m deep. Organic material is filled to ground level. The pit captures rain water, which makes this method of composting a valuable option in dry areas.	Burkina Faso
WOCAT2	Ridge & Basin	It is a rectangular shaped soil embankment created in digging up sol and farming ridge and a basin for harvesting moisture. It is rectangular soil embankment made with local implement called 'Bayra' and maintained every three years during dry season. The technology is applied on moderately deep soils. It is intended for moisture harvesting. Establishment is made by visual survey and then the soil excavated using local implement and maintained wherever there is a need for maintenance. Low and erratic nature of rainfall, shallow to moderately deep soils and medium textured soils are some of the governing factors for the technology.	Ethiopia
WOCAT3	Stone faced soil bund of Tigray	Stone walls placed downslope in an inclined manner having embankment of soil on upstream along the contour line having tie ridge. It is used to reduce soil erosion, shorten slope length and retain soil moisture. Along the contour 30 cm width and 420 cm depth of foundation is excavated and stones are placed up to a height of 0.5-0.75 with 1 m width and 30 cm top width. On the upper side embankment soil is added and a basin with 5-10 m tie is excavated. Integrated with biological SWC activities, farmers maintain and enhance vegetation growth, improve micro-climate, decrease land degradation.	Ethiopia
WOCAT4	Stone faced trench bund	It is an alignment of stones embankment at the lower/downslope of the trench dug to form earth embankment following a contour. It consists of digging a foundation, a stone wall construction of 60-80 m, and digging of trench along the contour The purpose is to reduce soil erosion, moisture harvesting, decrease slope length, reduce runoff velocity and increase productivity per unit area. It consists of planting of fodder trees and integrate with biological measures It enhances the potential to grow natural grasses and vegetation, minimize desertification, recharge ground water and improve local climate.	Ethiopia
WOCAT5	Stone faced level bund	Stone faced bund is embankment constructed from stone & soil along the contour at upper part to reduce velocity of run of & length of slope with collection ditch in the upper part. It is constructed	Ethiopia

		from soil embankment at the upper part. The layer of regular shaped stone embankment at lower side along the contour line. Excavated collection ditch at the upper part. It has a berm between collection ditch & soil embankment. The main purpose is to cut longer slopes into series of slopes, increase time of concentration & infiltration rate and decrease velocity of runoff. It also helps in collecting top soil, as a result to protect erosion, to increase yield at last forming a bench.	
WOCAT6	Area closure for rehabilitation	Enclosing and protecting an area of degraded land from human use and animal interference, to permit natural rehabilitation, enhanced by additional vegetative and structural conservation measures. Area closure involves the protection and resting of severely degraded land to restore its productive capacity. There are two major types of area enclosures practiced in Ethiopia: (1) the most common type involves closing of an area from livestock and people so that natural regeneration of the vegetation can take place; (2) the second option comprises closing o degraded land while simultaneously implementing additional measures such as planting of seedlings, mulching and establishing water harvesting structures to enhance and speed up the regeneration process. The focus of this case study is on this second type.	Ethiopia
WOCAT7	Dawa-Chea Traditional Checkdam	A structural measure constructed by stone/soil/wood across the gully to control erosion and create favorable condition for crop cultivation. The technology is known by the farmers for more than a century. Since the area is highly affected by gully erosion, this practice is widely used by farmers in the area and also widely practiced. Its construction starts from the bottom of the gully and proceeds upslope with different dimensions. The height depends on the depth of the gully and it is increased from year to year. On the average the width is 1m and height is 1.80m. The technology is used to develop big gullies and treatment of small gully like depressions, attain slope change to enhance land suitability to crop production and to conserve soil and water. The construction of the stone checkdam starts with small heights and some height is added every year until the intended height is reached. The increase in height could be done during maintenance also. The major objective being to stop gully growth, trap sediment and retain water running down the gully. In the course of increasing the height, the area for sediment deposition gets wider. The technology is suitable to areas with low rainfalls of rugged topography having a network of gullies.	Ethiopia
WOCAT8	Stablized Stone Faced Soil Bund	Stabilized bund constructed from stone and soils on the farm land along the contour and planted with multipurpose plant species. The stabilized bund is constructed on farm land to reduce slope length, angle and there by control soil erosion and enhance moisture/water retention capacity of soils. The bund is established along the contour by digging trench/foundation and place stone walls on the excavated trench. It is stabilized by planting grass. The structure is regularly maintained by repairing breaks. Some farmers put on additional height to the bunds as part of the upgrading practice. The technology is suitable to all agroecological conditions, where stones are available for construction.	Ethiopia

WOCAT9	DireDawa Traditional Checkdam	It is a stone wall built across a gully at a given interval to trap moisture and sediment for crop production. It is an embankment placed in the gully. It is constructed with stones. The purpose is to conserve and retain runoff coming from upslope. It is intended to trap sediment running from slopes. It converts gully land into cultivated. The establishment starts with a given height of stone wall which is increased every year as the need comes and when sediment fills up. It is essentially water harvesting practice and is very suitable in areas where moisture stress is high. At present new design and layout elements have been included to improve durability of structures and efficiency to store more water and soils. Top soils eroded from upper catchments and sedimented by the checkdams.	Ethiopia
WOCAT10	Chat Ridge bund	It is a mechanical conservation measure where a basin and a ridge are formed for planting chat along a contour. A contour line is made and a pit (trench) is dug and the soil embanked on about 75x50 cm. Chat cuttings are planted on the trench. The purpose of the technology is to collect as much water as possible. The embankment protects soil from erosion. Water is collected in the trench. Households using family labor make the ridge bund. During cultivation the ridge is strengthened. Maintenance is done in case of breaks on the ridge. The technology is suitable to semi-arid with rainfall 500-700 mm/annum. Farmers grow chat as the main means of finance/capital generation. Cultivation is done twice or three times.	Ethiopia
WOCAT11	Sorghum Terrace of Diredawa	It is a structural measure constructed across the slope to control erosion and increase soil moisture. Sorghum terrace of Diredawa locally called as Daga is constructed by placing stone walls across a slope following contour lines. The development of Sorghum terrace involves activities of creating an embankment at a given spacing, which depends on slope. Cultivation in the terrace is done by the use of Dengora (local name for spade like hand tool) if the land is sloping and by oxen if land slope is gentle (<8%). The purpose of developing Sorghum Terrace of Diredawa (STD) is to collect as much rainwater as possible for growing sorghum, which is planted by broad casting. Sorghum is the staple food in the area. Since rainfall is erratic, the STD allows more water to be stored in the soil. STD is maintained every year and also upgraded while performing different farm activities (Ploughing, Weeding, etc.,). Every time maintenance is made breaks in the terrace are repaired and additional height given to the terrace until it forms bench. STD is very suitable to areas with erratic rainfalls, sloping cultivated fields and land having abundant stones for construction. It is suitable to areas with semi-arid to arid climatic conditions and soils ranging from shallow depth to moderately deep.	Ethiopia
WOCAT12	Sweet Potato Ridge	Earth embankment formed by digging a channel and pile the soil to form a ridge on which potato is planted. Sweet potato ridge is constructed from the soil dug out of the furrow. Farmers make the furrow and ridge by dengora and a hoe. In some cases, oxen scoop is used to move the soil and form the embankment. Sweet potato is planted by cuttings. It is often planted during the end of the main rainy season. There are different methods employed in making ridge and furrows. The furrows are meant to collect rain water and the cuttings of sweet potato planted on the ridge. The plant benefits from the soil water stored by the furrows. It has deep roots that go deep in search of soil	Ethiopia

		water. Water could also move up by capillary movement. Forming the ridges and basin is quite labors. The ridges are frequently made new and in some cases the former ridges and furrows are maintained. The technology suits to sub-humid and semi-arid agro-ecological zones having sandy loam soils.	
WOCAT13	Rehabilitation of degraded lands	It is a combination of activities that help maintain the productive potentials of soils through prevention and reduction of erosion, enhancing of rehabilitation rate by practicing measures such as micro-basins, trench, eyebrow terrace, terraces, pitting and plantation of trees. The SWC technology comprises a combination of measures, which include agronomic, vegetative, structural and management measures. This means that in implementing the SWC technology combination of measures such as contour cultivation, grass strips, soil and stone bunds, area closure and improved grazing are applied in integration to rehabilitate degraded lands and restore their productivity. The purpose is to improve food security by reducing erosion and enhance the productivity of land by planting useful trees and fodder species. Unproductive land is changed to productive land by the practicing of the technology. The SWC technology is continuously maintained and improved to meet the standards and quality such that erosion is minimized. The technology is suitable to degraded and unproductive lands which were abandoned as result of low productivity and were previously under cultivation or grazing land. Closure of the area is followed by vegetative and structural measures to speed up the recovery/regeneration rate.	Ethiopia
WOCAT14	Microcatchments and ponds	Microcatchments and ponds are water harvesting measures used to collect stored and spread over an area to increase soil moisture and ground water level. Microcatchments for crop fields involve the construction of physical measures which trap rain water and help in increasing infiltration. Soil and stone funds, microbasins, ridges and tied ridges are some of the SWC practices known as microcatchment. They are designed taking into account the amount of rain received the infiltration capacity of soils and the runoff produced from the field. Water harvesting techniques described here are the most widely practiced techniques in Alaba woreda, which is characterized by erratic rains, soils having very low water holding capacity and farming systems dominated by seasonal cereal crops such as maize, teff, and pepper. Maize is the dominant food and cash crop grown in the wereda. It is a crop requiring more rainfall than teff and sorghum. Water harvesting techniques are more suitable to maize because these structures make more water available to the crop.	Ethiopia
WOCAT15	Soil bund & Fanya Juu combined & vegetated	Soil bund and Fanya Juu constructed along the contour lines in microwatershed to conserve soil moisture and control erosion. Purpose of the Technology: The main purpose is to trap as much rain water as possible and also control soil erosion. Cultivated lands with Soil bund and Fanya Juu have shown remarkable improvement in soil moisture availability to crops compared to fields with no measures. Soil bund and Fanya Juu constructed in combination in a microwatershed for retaining maximum possible rain water in the soil by obstructing runoff water. Soil bunds are suitable for steeper slopes compared to fanya juu terraces which are more effective in gentle and flatter slopes. Fanya juu which means throwing soil upslope in Kiswahili entails throwing soil upslope which is more	Ethiopia

		labor than throwing soil to downslope in the case of soil bunds. The other reason is that cultivated lands with fanya juu terraces are not easily accessed by free grazing livestock. The ditches placed in the downslope side of the embankment (fanya juu) is not easily crossable but in soil bund although not that easy livestock are seen to trample over the embankment and jump the ditch which is placed in the upslope side. The other advantage farmers consider is that Fanya juu is more efficient in controlling runoff because the water that overtops the embankment is trapped by the ditch. Fanya Juu despite its high cost is preferred to be applied in combination with bunds because of the other advantage that it forms bench terrace rapidly.	
WOCAT16	Bassin de captage des eaux de ruissellement Or Runoff harvesting basin	*Banka* or runoff water harvesting and storage structure. It is dug on the ground with a length up to 12m, 8m large, and 2m depth. It aims at collecting runoff for irrigation purposes during drought spells. The structure is rectangular with the bottom covered with plastic material to reduce water infiltration.	Burkina Faso
WOCAT17	Cordons pierreux isohypses/diguettes/demi lunes /labor/ terres /	It is a physical structure similar to stone bunds (or lines) associated with small dykes in the form of half-moons and small circular holes. The structure is built along the topography and aims at rehabilitating degraded soils by desertification or nutrient-poor soils.	Burkina Faso
WOCAT18	Soil faced deep trench bunds	They are sort of compacted soil bund constructed following a contour using a soil excavated from deep trenches on the up-slope side. Soil faced deep trench bund is constructed by excavating trenches of 1 m deep, 0.5 - 1 m wide and 2 - 3.5 m long with spacing between trenches of 0.3 - 0.5 m along the contour and using the excavated soil to construct a compacted bund downslope. The smaller dimensions are usually used in cultivated lands while the larger are implemented in grazing lands. The purpose of the technology: Soil faced deep trench bund decreases slope length, runoff velocity and soil loss; and increases runoff harvesting, soil moisture and groundwater recharge.	Ethiopia
WOCAT19	Use of organic matter (manure and compost)	Soils treated with compost or manure produce better yields, because they retain water better and are more fertile. The regular application of manure and/or compost in sufficient quantities makes farming more intensive and reduces the need to bring more land under cultivation. Manure is used on cropland and compost is recommended particularly for market gardening. The use of organic matter on cropland has three major effects: it reactivates biological activity, increases soil fertility by providing nutrients and improves soil structure by increasing the amount of organic matter in it. The improved soil structure also increases the infiltration of water into the soil.	Burkina Faso
WOCAT20	Parkland Agroforestry System	Parklands are the traditional agroforestry systems of semi-arid West Africa or Sahel where naturally growing, valuable trees are protected and nurtured on cropping and grazing lands. People rely on many locally cherished species to provide food and nutritional security for both human and livestock populations and to protect and enrich soils. Important used tree species are *Adansonia digitata, Tamarindus indica*, *Faidherbia albida*, *Vitellaria paradoxa*, *Parkia biglobosa,* etc.	Burkina Faso

WOCAT21	Assisted Natural Regeneration of Degraded Land	Assisted natural regeneration, as promoted by newTree in Burkina Faso, starts with enclosing 3 ha of degraded land with a solid fence. Fence materials (iron posts and galvanic wire) are externally sponsored and locally assembled and installed. Along the fence a dense living hedge of thorny trees (local tree species: e.g. *Acacia nilotica, A. senegal, Prosopis sp, Ziziphus mauritiana*) is planted. A strip of 10 m along the hedge is dedicated to agriculture. This area is equivalent to approximately 10% of the protected area. The rest is dedicated to natural regeneration of the local forest. Once protected, natural vegetation rich in endogenous species can actively regenerate.	Burkina Faso
WOCAT22	Solar cooker	The technology consists of harnessing solar energy through solar cookers. The basic principle of all solar cookers is to concentrate sunlight using a mirror or some type of reflective metal. It is used to concentrate light and heat from the sun into a small cooking area making the energy more concentrated and therefore more potent.	Botswana
WOCAT23	Game Ranching	The technology aims at conserving or sustaining rangelands through controlled grazing of wildlife enterprise. This is a community project that proposes to farm wildlife in a ranch. The community will seek the land through the Land-board authorities. Department of wildlife (which is in charge of wildlife) will be consulted on animal species to ranch or to bring in. The main inputs will include fencing the ranch, water provision and labor to run the enterprise (to be incurred by the community).	Botswana
WOCAT24	Trashlines	They are agronomic/structural measure using straw of maize and/or sorghum. Trashlines are constructed seasonally by the family members using maize and/or sorghum straws. It has multi purposes like water harvesting, soil trapping, soil fertility improvement, etc. It is common in gentle to steep slopes in semi-arid areas.	Ethiopia
WOCAT25	Hillside Terracing	A hillside terrace is a structure along the contour, where a strip of land is levelled for tree planting. Hillside terraces are up to 1-meter-wide and constructed at about 2-5 m vertical inteals. Hillside terraces should only be applied if there is a strong necessity of erosion control and/or water conservation justifying their construction. In Ethiopia and Eritrea, they have been mainly applied in the highlands, although the area of their applicability would be rather in the drier and lower lying agroclimatic zones. Slope range is 50-100%, soil range particularly on heavily degraded land. Hillside terraces are mainly used to prevent damage of flooding the area below steep slopes.	Ethiopia
WOCAT26	Stone faced trench	Construction of stones walls along the contour with trenches on the upper side of the structure while the upper part of the structure filled with soil and compacted alignment of the soil along the contour, digging of foundation, trench construction, spacing tie ridge, tree planting. The main purpose of the technology is to reduce erosion, increase soil moisture, recharge ground water, decrease ground water.	Ethiopia
WOCAT27	Stone bund of Tigray	It is an alignment of stone along the contour line which stabilizes with grass species. The construction of stone bunds along the contour to reduce soil erosion, conserve moisture, decrease	Ethiopia

		slope length, and to decrease downstream siltation. It is integrated with biological SWC measures and maintenance is made where ever necessary. The technique enhances the growth of natural grasses and improves the micro climate.	
WOCAT28	Area closure	Closure of degraded land is made on land that has lost vegetation cover, has low soil fertility. To speed up the regeneration process applying some SWC activities and enrichment plantation will be necessary. The degraded land is closed from human and animal interferences for at least 3-5 years. To enhance the rehabilitation rate of the degraded land SWC activities, such as terracing, enrichment plantation and over sowing of grass species is considered. These practices enhance growth of natural vegetation and enriches biodiversity.	Ethiopia
WOCAT29	Area Closure for Rehabilitation of Degraded Hillsides	It consists in closing the degraded land to provide enough time to regenerate by excluding from human and animal interference. The area is closed until the conditions are improved by revegetation and constructing structural measures. The technique is applied on steep slopes, shallow and denuded and environmentally sensitive areas. The purpose is to reclaim denuded land and make it productive and introduce effective use of the land. Through stabilizing the soil and regenerating of natural vegetation, helps to protect the downstream crop lands and other properties.	Ethiopia
WOCAT30	Jatropha curcas hedge	It is a vegetative measure for gully rehabilitation and hill stabilization with Jatropha hedges. In the area around Bati in Ethiopia, Jatropha is used to stabilize hills ore to rehabilitate gullies. The technology was introduced during the last decade by local farmers on their plots. The advantage of Jatropha against other shrubs is that it is poisonous and therefore not browsed by animals. Additionally, the seeds can be collected by household members and sold on the local market. The seed's oil can be used as a lamp oil or even for the production of bio-fuel. Besides hedges and living fences, Jatropha is used for combating sheet or gully erosion. To stop erosion processes the Jatropha cuttings are planted across a gully or along hill sides to stabilize them in the same manner as check dams or terraces do. The plant is chosen because of its very tolerant character, rather high accessibility in the area and because it is easy to propagate by cuttings. Often Jatropha is used in combination with traditional stone check dams or terraces aiming for an increased stability of the technology itself. For that purpose, Jatropha is planted in front of the stone walls or also on top of them.	Ethiopia
WOCAT31	Stone wall check dam	Stone wall check dams are built across a gully to collect alluvial soil and hinder further gully erosion. During the 1980s stone walls and terraces were introduced in Ethiopia to combat soil erosion. The technology of stone walls or terraces is used to stabilize hills or to refill gullies also in Bati, Ethiopia. Stone walls can form a very strong check dam to rehabilitate gullies even several meters deep. The technology used for different purposes, especially to combat gully erosion. Farmers in the Bati region often use stone walls to rehabilitate gullies if the material is easily accessible, otherwise they may search for alternatives.	Ethiopia

[WOCAT32]	Large semi-circular stone bunds	These consist of stone embankments built in the shape of a semi-circle with the tips of the bund on the contour and are arranged in staggered orientation in rows so that overflow from one row will run into the next downslope. Large semi-circular stone bunds are constructed by excavating a foundation of 0.1 - 0.2 m following the semi-circle and building of the embankment using stones with a decreasing height at the tips to evacuate excess runoff. 1 - 3 pits are excavated within the semi-circle for planting trees.	Ethiopia
[WOCAT33]	Check dam ponds	It is a raised wall constructed across a stream/gully using stone, concrete and/or gabion for dual purpose, namely, to pond/store the stream ow behind it for irrigation purpose while at the same time reducing the runoff velocity and enhancing gully rehabilitation. A check dam pond is a raised wall constructed across a gully from stone, concrete and/or gabion to store water behind it for irrigation purpose using either gravity or lifting mechanism. The structure generally consists of construction of foundation, apron, retaining wall and the checkdam. The width of the checkdam ranges between 1 - 2 m while the height varies between 1 - 2 m depending up on the gully depth. The length of the checkdam depends on the gully width. The spacing between adjacent checkdams is determined based on two factors, namely, the gradient of the river bed and the availability of potential land that can be irrigated. It is also provided with a number of sluice gates which will be removed during the main rainy season to minimize siltation. The purpose of the Technology is to store water for irrigation, and decrease slope length, slope angle, runoff velocity and minimize soil erosion.	Ethiopia
[WOCAT34]	Dams	Infrastructure of stone, mortar and concrete, built along the waterline, with the aim of retaining sediment dragged by water runoff, reduce the slope of the rivers and protect the bed, reducing the kinetic energy of flood water. Structures of large and long-term, in which the size depends on the slope of the stream and the soil and climate of the region. This installation also depends on the hydro-geology and topography and location of financial capital for its construction. The distance between two dikes, means are set, and is calculated by the slope of the bed, and the need to submit the site for its structure. It consists of an amount of vestment, an investment of downstream foundation, crest and wings. This technique is consolidated with techniques of correction of slopes, as barriers, such as live barriers, banquets, afforestation, and others, increasing your time of life.	Cape Verde
[WOCAT35]	Muret	Small walls of stone built on hillsides with slopes generally greater than 40%, second level curves, which ensures a good infiltration and contributes to reducing the erosive level curves, which ensures a good infiltration and contributes to reducing the erosive power of water runoff. Are usually constructed of stone with a height of 80 to 90 cm and width of 40 to 50 cm and a foundation of 30 cm, usually built on hillsides with slopes greater than 40%. The space between two consecutive Muret varies between 6 and 15 m, depending on slope, type of soil and plant cover and frequency of rainfall. Top Order capture water runoff by encouraging the development of plant species. When complemented by banquets and entertainment channels to facilitate drainage of surface water to the adjacent lines. Also this technique can be complemented with vegetative measures. This	Cape Verde

		technique is used mainly for agricultural land in rain with the aim of protecting slopes from erosion, and to practice the culture of *Cajanus cajan* and other forage species.	
WOCAT36	Reforced terraces for stone walls	The reforced terraces for stone walls are platforms created in series along the slopes, separated by punch of stone, vertical, reduced the length of slopes and facilitating the infiltration of water and increasing reduced the length of slopes and facilitating the infiltration of water and increasing production. The terraces, platforms are created on the slopes, where the slope exceeds 30, to reduce or eliminate the gradient of the slope, creating an agricultural field with better soil fertility. Such platforms have 5% inclination to the inside retaining more water to its surface, and 1% of the drainage along gradient, in case of saturation of soil in water. The separation between two platforms is performed by punches from the local stone, that structure has to be calculated, taking into consideration the slope, the width of the platform, climatic conditions and other variables. Its primary objective is to adapt the land to use it intends to take to eliminate the slope of the hill, working to increase soil moisture, the reduction of runoff, and its kinetic energy through the punches.	Cape Verde
WOCAT37	Barreiras Vivas de Leucaena	It is a vegetative measure based on the planting of the bush, *Leucaena leucocephala*, on line along the level curves in the steep slopes. The technique consists of planting rows of *Leucaena leucocephala* in the level curves along the slopes. This legume has high rate of reproduction and the permanence of their seeds in the soil can reach 10 years before germination. It is very resistant to fire and to pruning. Can reach 4m in height and if not controlled, can invade a field of culture. The plant has great potential for feeding of livestock (protein (21-26% DM), fiber (15-25% of crude cellulose MS) vary depending on the age of the plant). The planting in curves level is to achieve the stabilization and restoration of degraded soil. The technique reduces the runoff, retain sediment, solid, incorporates greater quantity of organic matter in the soil, promotes infiltration and covering the soil with vegetation.	Cape Verde
WOCAT38	Permeable rock dams	Permeable rock dams serve to restore seriously degraded farmland and forest/rangeland and are used to fill in gullies and control water flow. They slow the flow of floodwaters and spread the water over adjacent land. The permeable rock dam is a structure built in gullies using loose rocks and stones and sometimes reinforced with gabions. A filtering layer (blanket of gravel or small stones) is laid in a foundation trench. Further layers of medium-sized and large stones and rocks are laid on top. They are between 0.50 and 3m high, and the width of the foundation and the crest depends on the estimated volume of water flow. The structure built across the gully is extended to the sides with the construction of wing walls that spread the water over a larger area to the sides of the dam. The total width of the structure is generally at least three times its height. The dams can be constructed with or without a spillway.	Burkina Faso
WOCAT39	Permeable rock dikes	Permeable rock dikes are erosion control structures built along the natural contour of the land and designed to slow down runoff. They are built between 30 and 50 cm high and twice or three times as wide as they are high. They are made with different-sized stones and rocks, and the crest of the	Burkina Faso

		dike is horizontal. There are two main types of permeable rock dike: those without a filter layer, which are suitable for flat land with no gully erosion and those with a filter layer suited to land with heavy runoff.	
WOCAT40	Afforestation and Hillside Terracing	Tree plantations in combination with hillside terracing to protect upper catchment areas are a widespread technology in the Central and northern Highland Zone of Eritrea. In the early 1990s a large area was treated in the Toker catchment, northwest of Asmara. The first step was to establish hillside terraces on the steeper slopes where it is essential to conserve soil and water for improved growth of trees and other vegetation. The terraces comprise earthen embankments laid out along the along the contour, reinforced with stone risers, combined with a trench on the upper side to harvest runoff water. The trenches are subdivided into basins (by ties) to avoid lateral ow of runoff water. In a second step, trees were planted at a spacing of 2 m (in the trenches). Mostly fast growing eucalyptus was used, with a very small percentage of the indigenous African olive (*Olea africana*) - which has good survival rates but grows very slowly. Afforested areas are closed for any use until the trees reach maturity: they are protected by guards.	Eritrea
WOCAT41	Konso Bench Terrace	It is a stone wall embankment along the contour with land leveling in between two terrace walls to control erosion. The traditional Konso Bench Terraces are established by building up stone embankments along the contour and gradually levelling the land in between risers. Levelling is done actively and by siltation processes. Stone walls have to be enhanced periodically. The appearance of the technology evolves over time from stone embankments to bench terraces. The stone walls are supported on the downslope side by trees and / or legumes including coffee, pigeon pea, etc. The purpose of the structures is to break the slope length and reduce run-o concentration thereby controlling erosion, increasing water stored in soil and harvesting eroded sediments.	Ethiopia
WOCAT42	Organic cotton	Organic cotton production adheres to the principles and standards of organic farming. Any application of synthetic fertilizers and pesticides and the use of genetically modified varieties are forbidden. Organic cotton relies on a combination of different measures: (1) the use of organic fertilizers (manure or compost) and recycling of organic matter; (2) Crop rotation and/or intercropping; (3) Careful selection of varieties adapted to local conditions (climate, soil, pests and diseases); (4) Biological pest management (in combination with careful monitoring of crops); (5) Clear separation of organic and conventional cropland, e.g. by growing border crops (to avoid contact with chemical substances through spray drift or surface runoff); and (6) Soil and water conservation measures.	Burkina Faso
WOCAT43	Runoff/floodwater farming	Runoff/flood farming locally known as Korbe is a practice that involves diversion of water from different sources for growing vegetables, fruit trees and crops of high value on a land prepared known as Korbe. Runoff and floodwater farming is a traditionally practiced water harvesting system which helps overcome problems of soil moisture and crop failure in a hot, dry area with erratic rainfall and shallow, highly erodible soils: Flood water and runoff from ephemeral rivers, roads and hillsides	Ethiopia

		is captured through temporary stone and earth embankments. A system of hand dug canals – consisting of a main diversion canal and secondary / tertiary canals – conveys and distributes the captured water to the cultivated fields in naturally at or leveled areas. The total length of the canal system is 200 – 2000 m. The harvested water is used for growing high value crops, vegetables and fruit trees. Irrigated fields are divided into rectangular basins bordered by ridges to maximize water storage and minimize erosion risk.	
WOCAT44	Micro-catchments for rainwater harvesting	Ox-ploughed furrow micro-catchments are intentionally built as part of seedbed preparation to harvest rainwater. Commonly used in dryland environments, the micro-catchment prolongs water availability for seed germination and growth and development of the emerging seedlings. Creation of furrow micro-catchments using an ox-driven plough is a traditional seedbed preparation practice among agropastoral communities inhabiting arid and semi-arid environments in Kenya. The process involves minimal soil disturbance by intentionally creating shallow furrows (about 20 cm depth) using an ox-driven plough. Oxen commonly used predominantly have a light and bright skin coat. This is aimed at reflecting away excess heat from the sun. Consequently, the oxen are less fatigued and can therefore plough for a longer period of time. The furrow microcatchments are intentionally created across the slope to harvest rainwater to prolong water availability for seed germination and subsequent growth and development of emerging seedlings. Furthermore, the ox-plough breaks the soil hard-pan common in dryland environments. Therefore, the microcatchments also facilitate seedling root penetration to the lower horizons. Prolonged water availability, especially in dryland environments, promotes growth and development of fast growing and early maturing drought tolerant crops and indigenous pasture production, consequently better crop yields and pasture production.	Kenya
WOCAT45	Community supported pasture and rangeland rehabilitation works	The technology consists of the rehabilitation of rangelands involves selection of key pasture and fodder species, and their reintroduction into strategic areas through stakeholder participation. The technology is also supported by communal management plans, which were created to address the root causes of land degradation. This technology was developed and implemented through the RETESA Project “Land rehabilitation and rangelands management in smallholder agropastoral production systems in south-western Angola”.	Angola
WOCAT46	Grass reseeding	Grass reseeding is a sustainable land management practice aimed at rehabilitating degraded pastures and providing livestock feed. This is mainly carried out with indigenous perennial grass species. Grass reseeding is a sustainable land management practice, especially appropriate for pastoral and agro-pastoral communities inhabiting the arid and semi-arid rangelands of the world. Seedbed preparation involves clearing of invasive bush patches and creation of furrows across the slope using an ox-plough (traditional) or shallow and light ploughing using a tractor (modern). Grass seeds are sown along the furrows which are created directly in the degraded grazing land. The seeds are lightly covered with soil because the indigenous grass seeds are very small. This encourages faster emergence of grass seedlings. The slope should be generally at or very gentle	Kenya

		(<5%) to reduce the speed of runoff, thus prevent soil erosion and consequently the washing away of the grass seeds. Eroded and deposited seeds will eventually lead to uneven establishment of pasture, mainly concentrated downslope. Minimal soil disturbance by ox-plough or tractor facilitates root penetration of the seedlings and also helps breaking the soil surface hardpan formed by continuous hoof action.	
WOCAT47	Il Ngwesi Group Ranch Grazing with Holistic Management Principles	A group ranch belonging to the Masai (traditionally, nomad pastoralists) has applied "Holistic Management" grazing principles. The principles consist of separate, planned grazing in villages during the rains, then "bunching" and moving of all animals in herds during the dry season. Denuded land is recovered by a "Boma" technology: i.e. strategic corralling of animals overnight, and reseeding. On Il Ngwesi Masai Group Ranch, livestock production management is a combination of traditional livestock keeping and holistic grazing management principles which were introduced in 2007. Livestock production at Il Ngwesi is for subsistence and sales – and has very high cultural signicance. 80% of the land is used for conservation, where wildlife and their habitat are protected. The vision is to integrate community development and sustainable environmental management.	Kenya
WOCAT48	Borana Ranch Grazing with Holistic Management Principles	Borana is a private ranch which combines livestock production with conservation and tourism. "Holistic Management" is applied as a principle for livestock on semi-arid lands tourism. "Holistic Management" is applied as a principle for livestock on semi-arid lands with limited water resources. Grazing comprises "bunching" and rotational movement of livestock with limited water resources. Grazing comprises "bunching" and rotational movement of all animals in herds. Livestock production on Borana ranch is carried out under extensive grazing for beef, dairy, and sheep production. There is strategic fattening and offtake for sales in harmony with conservation principles. The Borana Conservancy is a non-profit organization, also belonging to the ranch – on the same land - dedicated to the sustainable conservation of critical habitat and wildlife. Ranching contributes financially to the running of the conservancy.	Kenya
WOCAT49	Lolldaiga Hills Ranch: Rotational Grazing and Boma-Based Land Reclamation	Lolldaiga Hills ranch is a private ranch and conservancy with livestock production and tourism. Rotational grazing is used to manage livestock on semi-arid lands with limited tourism. Rotational grazing is used to manage livestock on semi-arid lands with limited water resources. Bare land is recovered by a "Boma" water resources. Bare land is recovered by a "Boma" technology – strategic corralling of technology – strategic corralling of animals overnight on degraded land. Livestock production on Lolldaiga Hills ranch is managed under an extensive grazing system for dairy, beef, sheep and camel production, with strategic fattening and selling, in harmony with conservation principles. The conservancy is dedicated to the sustainable conservation of critical habitat and wildlife. The ranch serves also as a training ground for the British Army.	Kenya
WOCAT50	Afforestation	Afforestation is one of the key technologies to address the fragility of ecosystems: it provides better protection against erosion and makes better use of rainfall to provides better protection against erosion and makes better use of rainfall to maintain the sustainability of agricultural systems.	Cape Verde

		Mountain forest areas are considered protective due to their role in regulating water (infiltration of storm water, regulation of surface runoff, and ground water recharge) within the watershed. The main species used are *Prosopis juliflora*, *Parkinsonia aculeata*, *Jatropha curcas*, *Atriplex spp, Acacia holosericea, Acacia victoriae, Lantana camara* and others, in arid areas and *Eucalyptus camaldulensis*, *Grevillea robusta*, Pinus and Cupressus ssp. in highland and humid areas. The aim is to maximize retention of water and control surface runoff. This not only allows better infiltration of water for the tree plantations, but also protects against soil erosion and facilitates groundwater recharge.	
WOCAT51	Aloe Vera Living Barriers	It is a technique which uses the structure of a cross-slope barrier of *Aloe vera* to combat soil erosion by decreasing surface wash and increasing infiltration. *Aloe vera* is a durable herbaceous plant which is planted in the form of living barriers to recover degraded slopes on the Cape Verde Islands. The main purpose of the technology is to build an efficient barrier for retention of eroded sediments and surface runoff. The living hedges of *Aloe vera* stabilize the soil, increase soil humidity by improving infiltration and soil structure. Groundwater is recharged indirectly. Soil cover is improved, and thus evaporation and erosion reduced.	Cape Verde
WOCAT52	Split Ranch Grazing Strategy	Split Ranch Grazing involves grazing half the available area for a full year concentrating livestock. The consequent grazing pressure maintains the grassland in an immature, high-quality state, while resting the other half, allowing optimal recovery from the previous full years grazing. The Technology is simple, requiring less fencing than more complex systems, without compromising sustainability or ecological function. These concepts can also be used for management in pastoral wildlife systems to create habitat heterogeneity (short and tall grassland).	Botswana
WOCAT53	Sand dune stabilization	Sand dunes are stabilized with vegetation to reduce wind erosion and the amount of sand blown onto cropland, dwellings and other infrastructure. This measure is used to stabilize sand dunes in locations and villages where there is a risk of sand covering cropland or infrastructure (buildings, roads, irrigation systems, etc.). Dune stabilization is achieved by setting up windbreaks arranged in a checkerboard pattern, with each side measuring between 10 and 15 m. The windbreaks are formed by palisades made from millet stalks or other plant material or by hedges and trees (*Leptadenia pyrotechnica, Euphorbia balsamifera, Acacia raddiana, Acacia senegal, Balanites aegyptiaca, Prosopis juliflora*, etc.). They provide protection from wind erosion and reduce the amount of sand blown onto cropland, dwellings and other infrastructure which can prevent extensive damage. Grass and shrubs are planted in strips in the fenced-off areas to further stabilize the soil. The palisades and vegetation provide shade that lowers soil temperatures and the organic matter and waste improves the soil structure.	Niger
WOCAT54	Sand dune stabilization	It is a combination of three measures to stabilize dunes: area closure, the use of palisades, and vegetative fixation through natural regeneration as and vegetative fixation through natural regeneration as well as planting. In the Sahelian zone of Niger, sand dune encroachment can lead	Niger

		to loss of agricultural and pastoral land, and threatens villages. These dunes may form as a result of an increase in wind erosion, but more frequently originate from formerly stabilized dunes that have become mobile again following the disappearance of vegetation. Vegetation loss may occur through a combination of unfavorable climatic conditions and overexploitation by grazing and fuelwood gathering.	