# Technical Report

## Restoration of Degraded Lands in West Africa Sahel:
Review of experiences in Burkina Faso and Niger


Written by
**Boubie Vincent Bado (ICRISAT)**
**Patrice Savadogo (ICRAF)**
**Maman Laminou Sanoussi Manzo (ICRISAT)**


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# Table of Contents

## 1. Introduction

Water constraints and the inherent soil poverty are the major factors that limit crop yields and productivity of cropping systems in West Africa Sahel (WAS). Livestock is not well integrated with agricultural activities and crop residues are usually exported from the farm for household needs and animal feeding. In traditional systems, soil fertility maintenance was based on a relatively long fallow period (10-15 years) followed by a short cropping period of 3 to 5 years. But the increased population pressure has resulted in significant changes of the traditional bush-fallow system. Lands are now continuously cultivated for long period with low external inputs, leading to soil fertility decline over time (Bationo and Mokwunye 1991; Bekunda et al. 2010). In addition to biophysical aspects, a wide range of socio-economic factors such as the low financial capacities of poor farmers to invest in agricultural inputs, high pressure on ecological resources for food, fodder or energy, also add to the stress on the systems. Failure by the smallholder farmers to intensify agricultural production in a manner that maintains soil productivity is the main cause of land degradation, particularly in the fragile ecosystems of WAS.

Land degradation is defined as a process that leads to the reduction of land productivity for useful purposes, and is typically a result of soil, wind, or water erosion; soil salinization; waterlogging; chemical deterioration; or any combination of these factors (Adeel 2003). Land degradation is a global problem, particularly in the dry areas, home to a large population of poor farmers, where land degradation and water scarcity are major threats to food security. The impacts of land degradation are severe on both human society and ecosystems. Desertification is often wrongly attributed solely to droughts, but it is the deadly combination of continued land abuse during periods of deficient rainfall that results in unproductive land, and ultimately desertification (UNESCO 2003). Combating desertification by rehabilitating degraded lands can be done successfully, using existing, often traditional techniques.

Land restoration involves restoring the fertility of degraded lands. The social syndrome where diminishing availability of lands, inherent low fertility, continuous soil erosion, and continuous nutrient removal without replenishment, results in a spiraling downfall in productive capacity and a diminished resilience of the soil system to provide a suitable medium for crop growth needs to be addressed. Smallholder farmers are at the center of both soil fertility decline and restoration process. Their decisions to manage, to utilize technologies and to improve or restore soil fertility are guided by the socioeconomic conditions and the overall benefits that will accrue from production (Sanginga and Woomer, 2009; Bekunda et al. 2010). A sustainable management of lands under cultivation and the restoration of degraded lands could be achieved by affordable strategic management innovations; taking into account the socioeconomic conditions of farmers. While individual technologies can contribute; a more integrated systems that combines technologies, crops, and trees such as the agroforestry systems could better contribute for sustainable management of natural resources.

Many efforts have been invested to developing strategies and approaches for both sustainable management of natural resources and restoration of degraded lands in WAS. In some cases, farmer communities have developed sound, sustainable approaches to land rehabilitation and management but there is insufficient information on successful restoration in the context of WAS, particular with regards to policy, institutions and socioeconomic conditions under which specific approaches could be adapted and applied successfully (Bunning 2003). The main objective of this review was to investigate the main experiences of regenerating degraded landscapes (RDL) in Niger. Going through the documentation, we found many similarities in experiences across the two countries of Niger and Burkina. Some interesting experiences were found in Burkina, Niger or at the same time in the two countries. We finally decided to extend the review to the two countries as a representative zone of the WAS. The critical issue in taking restoration to scale is that ecological, economic and institutional context varies at fine scales. The main goal of this review is to identify the specificities and the context of the most efficient experiences of RDL that could be widely scaled in the WAS.

## 2. Land degradation in West Africa Sahel

Large areas of WAS are prone to land degradation. There is a permanent competition for moisture and nutrients for crops, fodder, energy, etc., leading to the removal of crop residues and protective grass cover, and with frequent droughts, this leaves the soil highly vulnerable to wind erosion. Heavy grazing prevents or delays regrowth of the vegetation, wind erosion removes topsoil, while blown sand may damage crops or cover croplands. Heavy rains following a long dry period, may seal the soil surface, cause runoffs, and erode bare soil. Many areas of WAS have become more vulnerable to degradation, particularly from 1930s to 1960s (Bunning 2003).

Degradation and restoration is a continuous process. Core components of land restoration are recovery of vegetation and the improvement and maintenance of the soil health. Reduction of land productivity and the high population growth leads to high pressure on the cultivated and marginal lands. The immediate causes are deforestation, poor management of water resources, decrease in soil fertility; increase of cultivated lands; the vicious cycle (Adeel, 2003).

The main agro-silvo-pastoral zone of Burkina and Niger are localized in the dry semi-arid zone of WAS (Figure 1). In Burkina Faso, 34% (92,345 million ha) of cropland are degraded. It is estimated that 100,000 to 250,000 ha of land are annually degraded and 74% of land are degraded or prone to degradation (Hien 2015. In Niger, 40-50% of the lands were affected by deforestation in less than 30 years (between 1958 and 1997). Around 80,000 to 120,000 ha are annually degraded. The countries of WAS have put many efforts to combat desertification and restoration of the degraded lands. An intergovernmental institution named ''Inter State Committee against Desertification in the Sahel'' (CILSS in French) was created after the drought in the years 1970s. Many programs and projects have been implemented by CILSS in its member countries. Some were regional, covering two or more countries but others were designed for national or local specific actions. Many successful experiences were obtained, along with some failures. The CILSS has made an effort to document its 40 years experiences to combating desertification (Hien et la., 2015. Apart from this documentation of CILSS, there have been a few syntheses on the broad effectiveness to address land degradation and the restoration experiences although there have been many accounts of individual successful efforts that have been summarized as good practice, including a set of lessons learned from the rehabilitation of degraded lands (UNESCO, 2003; Blay et al. 2004). Few of these efforts have gone so far as to critically assess the elements that allowed them to make large-scale impacts. Before making the review of technologies and experiences, the history of the actions against land degradation could help to better capture the evolution of the concepts, strategies and the innovative adaptations.

## 3. History of restoration of degraded lands in West Africa Sahel

The countries of the WAS were already working on RDL before the creation of CILSS, the intergovernmental institution. Depending of the country, different initiatives and projects were implemented at local or national levels.

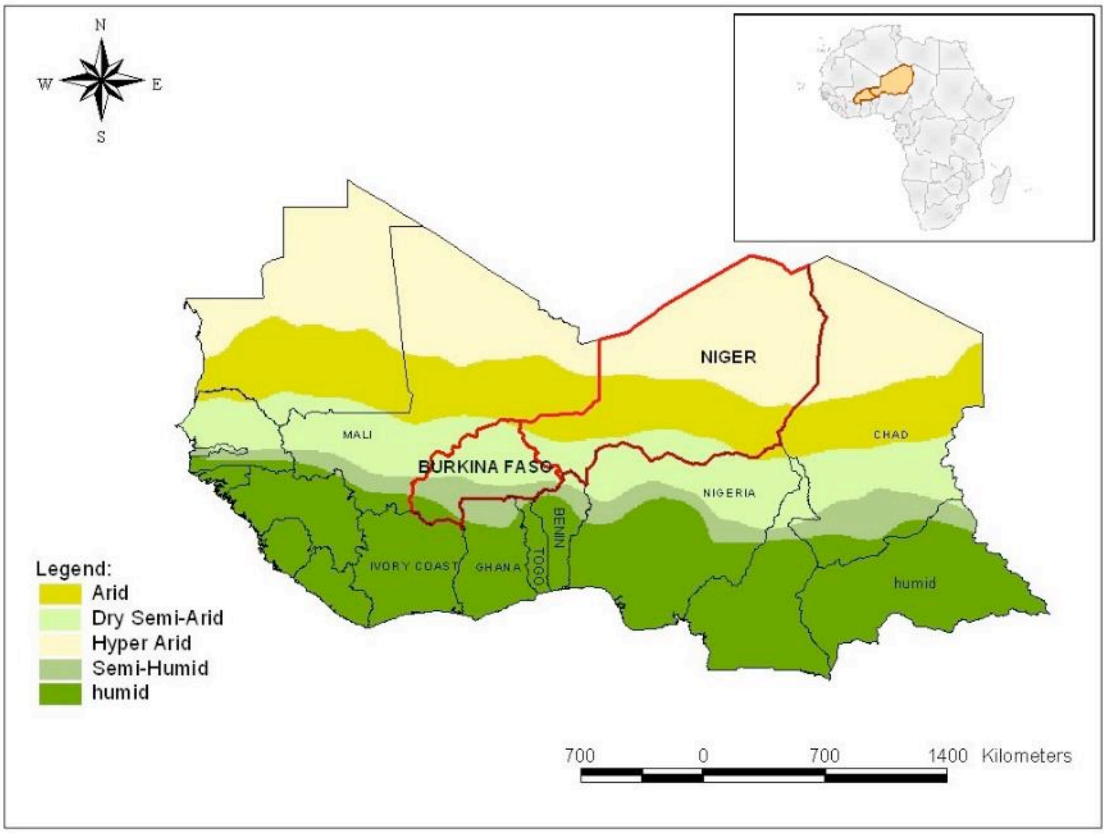


*Figure 1. Ecological zones of Burkina and Niger in West Africa Sahel.*

### 3.2 Burkina Faso

The initiatives of RDL in Burkina started in 1960 with the project "GERES Volta" (Hien 2015). This project aimed to create a "psychological shock" to raise awareness of the degradation of agricultural lands using traditional techniques. The project set up 120,000 ha of degraded lands treated with anti-erosion techniques using the earthen benches. With the participation of communities, trees and strips Andropogoneae were planted along the benches. Other actions were undertaken in the 1970s. The program ''Development of Authority Volta Valleys'' (AVV) which became ''National Office for Land Management'' (ONAT), introduced the techniques of "stripes". In 1976 the Water and Rural Equipment Fund (FEER) launched a program on Restoration of soils (DRS). From 1980s and taking advantage of the experience of FEER, more integrated approaches were developed with the "integrated development projects". The earth benches were replacing by stone bunds. Many NGOs and projects have invested majorly in these integrated management techniques. Most innovations in RDL originate from these experiences.

### 3.1 Niger

As in Burkina, the first actions of RDL in Niger started in 1960 (Hien et al., 2015). The techniques of half-moons, stone bunds and benches were introduced later. The strategies of "food for work" and/or "cash for work" were used to mobilize communities, but the actions were often punctual with limited impacts. Significant results were obtained in the RDL since the drought of 1970s, with strong political engagement. A new strategy involving the communities was adopted as an essential element of sustainable management and RDL. The national strategy states that: 'the fight against desertification for food security must contribute to improving production systems as part of the search for food self-sufficiency''. Many concrete actions have supported this political commitment. Following the severe food crisis of 1984-1985, IFAD's support through its Special Programme for sub-Saharan African countries, strengthened the actions of RDL in the Sahel, particularly in Niger. Building on indigenous practices and technologies, the program contributed significantly to the RDL in Niger.

## 4. Experiences of restoration of degraded lands

The techniques of RDL vary from simple individual technologies to more complex systems combining one or more technologies with management practices. The individual technologies of RDL are generally developed, adapted or improved from traditional practices by researchers. In the scaling process, farmers tend to adapt or combine the new technologies with their own practices. At farmer's level, there is no clear barrier between technologies for RDL or sustainable management of lands (SML). Depending of the biophysical and socioeconomic conditions, they adopt or adapt one, two or more techniques to manage their cropping system. Many of them have been identified. Some are widely used at regional level while others are more localized. The CILSS made a descriptive inventory of these techniques and their performances (Hien et al., 2015). An inventory from individual technologies to more complex systems could help understand the technical progress under RDL in WAS.

### 4.1 Vallerani system

The Vallerani system is a relatively new system of water harvesting where a special tractor-pulled plough is used to automatically construct water-harvesting catchments. This system is ideally suited for large-scale reclamation work. The Vallerani implement is a modified plough named Delfino3, pulled by a heavy-duty tractor (Figure 2). The Delfino3 plough has a single reversible ploughshare that creates an angled furrow and piles up the excavated soil on the lower (downhill) side of the furrow. This soil forms a ridge that stops or slows down runoff water as it flows downhill. The Vallerani system is intended for use with direct sowing of seeds of shrubs and trees. Seeds are sown along the ridges of the basins and in the wake of the ripper. With more moisture available for a longer period of time, trees grow rapidly and the herbaceous cover improves in quality and in quantity; providing 20-30 times more livestock fodder (1,000 - 2,000 kg dry herbaceous biomass/ha/year), and also helps conserve the soil (Schmidt et al. 2010; Mekdaschi Studer and Liniger 2013; Ray and Simpson 2014).

*Figure 2. Vellerani system to create water harvesting catchments. Photo: W. Critchley from Mekdaschi Studer and Liniger (2013)*

### 4.2 Planting trenches

The main purpose of this technique is to restore tree cover and prevent soil erosion on the slopes by reducing water flow that threatens the land in the downstream. The established trenches reduce gully erosion and sedimentation of areas with a fragile soil structure. It permits the reintroduction of trees on degraded, unfertile land and contributes to dissipating the force of runoff and increases infiltration. Areas restored using planting trenches can subsequently be exploited to a limited extent in accordance with careful management practices. The infiltration of water into planting trenches can contribute to groundwater recharge. This technique has proved effective in restoring forest/ rangeland on highly degraded sites. The progressive development of grass and tree cover continues on these sites for years after its establishment. However, the young trees must be monitored for several years to ensure that stray grazing animals do not damage them and dried up plants /trees must be replaced (GIZ, 2012; Ray and Simpson 2014).

## 4.3 Contour ridges/tied ridges

Contour ridges or contour plowing, are commonly used worldwide in crop production. This is a microcatchment technique. Ridges follow the contour at a spacing of usually 1 to 2 m. Runoff collects and is stored in the furrow between ridges. Crops are typically planted on the ridge tops. Additionally, ties can be added to the system, consisting of low ridged or barrier, between the principle ridges, thus creating microcatchments within the furrows. The use of ties is helpful in preventing water from accumulating in low spots and potentially breaching ridges on slopes. The ties are particularly useful on undulating terrain, or in situations where precise contouring is not possible. The system, with or without ties, is simple to construct and amenable to use with animal traction or tractors. Special attachments (for animal traction and tractors) are available to facilitate creation of "ties." The yield of runoff from very short catchment lengths is extremely efficient and when designed and constructed correctly there should be no loss of runoff out of the system. Another advantage is an even crop growth due to the fact that each plant has approximately the same contributing catchment area (Deuson and Sanders 1990; Critchley et al. 1991; Ray and Simpson 2014).

## 4.4 Contour bunds

Contour bunds are used in crop agriculture and the establishment of trees. As the name indicates, the bunds are established following the contour, at close spacing. With the optional inclusion of small earth "ties," formed laterally between the bunds, the system can be divided into individual micro catchments (Figure 3). The construction of contour bunds lends itself to mechanization (animal-traction and/or tractors). The technique is therefore suitable for implementation on a larger scale. The major advantage of contour bunds is their suitability to crop cultivation between the bunds. As with other forms of microcatchment water harvesting techniques, the yield of runoff is high, and when designed correctly, there is no loss of runoff out of the system (Critchley et al. 1991 Nagano et al. 2002; Ray and Simpson 2014).

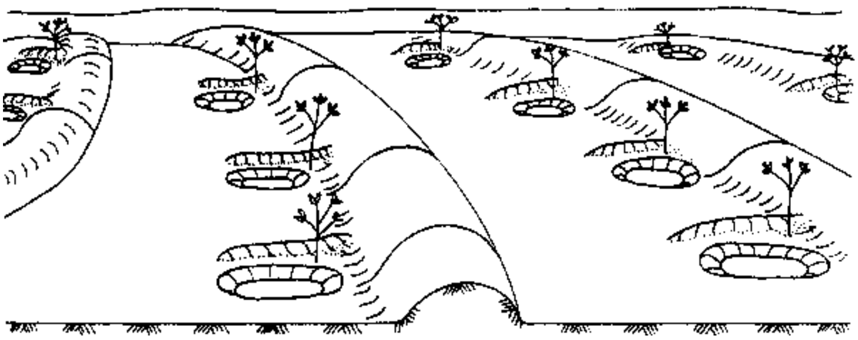

*Figure 3. Contour Bunds for trees, Caffrey et al. (2014). Credit: Critchley et al. 1991*

## 4.5 Contour stone bunds

The use of bunds, or lines of stones, is a traditional practice of Sahelian West Africa, notably in Burkina Faso (Ray and Simpson 2014). Contour stone bunds are used to slow down and filter runoff, thereby increasing infiltration and capturing sediment. The water and sediment harvested lead directly to improved crop performance (Figure 4). This technique is well suited for small-scale application on farmer's fields and, given an adequate supply of stones, can be implemented quickly and cheaply over large areas. The great advantage of systems based on stone is that there is no need for spillways, where potentially damaging flows are concentrated. The filtering effect of the semi-permeable barrier provides a better spreading effect of runoff than earth bunds, which attempt to capture runoff. Furthermore, stone bunds require much less maintenance, although periodic maintenance is required, especially to repair damage caused by cattle movement. The use of stone bunds for water harvesting has evolved into various forms, making it an effective technique which is both popular and quickly mastered by farmers (Critchley et al. 1991; Somé et al. 2000; Nyssen et al. 2007; Ray and Simpson 2014). But one main constraint of this technique is the unavailability of stones in some places such as in regions with sandy soil.

*Figure 4. Implementation of the contour stone bands. Photo: Hien F*

## 4.6 Contour line cultivation

A variation in the use of contour bunds, the Contour Line Cultivation (CLC) or Aménagement en Courbes de Niveau (ACN) in French, is a holistic landscape approach to manage water and capture rainfall on a watershed scale. The approach was developed in Mali by researchers of the Institut d'Economie Rurale (IER) and Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD). The principal objectives of the CLC technology are: a) to capture and retrain rainfall in treated fields, b) assist evacuation of excessive rainfall and destructive surface flow that may run onto fields during heavy storm events. The system consists of establishing permanent ridges (Ados) about 100 cm wide that are constructed on the contour and maintained in subsequent years. Smaller ridges are then established through normal plowing that follow the contour indicated by the permanent Ados. Other structures may be required, such as overflow or evacuation channels to remove excessive water. Treated fields can increase infiltration of rainwater by up to 10% of the total annual rainfall, even in fields with a gentle slope of 1 to 3%. The increased rates of water infiltration with ACN suggest that the reduction in surface runoff of rainwater results in greater capture and deeper percolation of water into the soil (Kablan et al. 2008; Ray and Simpson 2014)

### 4.7 Vegetative strips

Vegetative strips, either naturally occurring or planted, are traditionally used to demarcate and protect fields by farmers in various parts of Africa. The recommended use of contour barriers, vegetative barriers and hedgerows of multipurpose trees, have been promoted in various forms since the 1980s. Technically, vegetative strips are narrow bands of naturally occurring or planted grasses, other plants and trees. Contour lines are laid out and staked to serve as an initial guide for plugging, with wide strips left unplugged to allow vegetation to establish. Alternatively, the staked contours are used to guide the planting of species, such as vetiver grass. In either case, rainfall runoff flowing downslope is slowed, and infiltrates when it reaches the vegetative strips. As the water movement slows, suspended soil particles collect above the strips and natural terraces form overtime. This leveling is assisted by plugging along the contour between the strip which causes some 'tillage erosion' that also moves soil downslope. Vegetative strips constitute a low-cost technique with modest labor demands for establishment and maintenance. Land users appreciate the technique because it effectively controls soil erosion and prevents loss (through surface runoff) of fertilizers applied to the crop. As an option, some farmers plant trees on or above the vegetative strip. This may be during the establishment of contour lines or later. The trees and other cash perennials provide an additional source of income at the cost of some shading of the adjacent annual crops (Liniger et al. 2011; GIZ 2012; Ray and Simpson 2014).

The performances of vegetative trips are similar to those of stone bunds. The can reduce runoff and soil erosion from 51% and 34%, respectively with a significant increase in crop yields. They also provide fodder for livestock and material for various domestic needs (home, beds, energy, etc.). It is fairly simple, cheaper and therefore accessible to poor farmers. The cost of implementation is estimated at US$100/ha (Hien et al., 2015).

### 4.8 Mulching

Mulching is another traditional technique that usually involves leaving millet and sorghum stalks in the field after harvest. In cases where a relay crop has been planted, such as watermelon, the stalks serve to reduce the evaporation of remaining moisture from the soil and acts as a barrier and prevents wind erosion, helping trap the thin rich dust carried by the *harmattan* wind. Through action of termites, the stalks and branches are broken down and gradually decompose to get incorporated into the soil profile, providing nutrients and improving the soil structure. When accumulated in a single location and combined with a temporary coral, the stalks serve as feed and bedding for livestock, and are effective for restoring infertile patches of cropland. Mulching can be combined with any other erosion control technique such as the contour stone bunds or grass strips and is a central component of conservation agriculture (Lamers et al. 1998; GIZ 2012; Ray and Simpson 2014). But the growing demand for biomass for household and livestock needs is a limiting factor for this technique.

### 4.9 Sand dune stabilization

Stabilization of active sand dunes is achieved through a combination of mechanical measures (such as palisades) and biological measures (such as live fences and sowing grass) (Ray and Simpson 2014). These measures seek to stop sand encroachment and stabilize sand dunes on-site in order to protect villages, cultivated land, roads, waterways and other infrastructure. In addition to moderating temperatures and mitigating the impact of wind, benefits of dune stabilization includes increase in: a) soil cover; b) biomass/aboveground carbon sequestration and storage; c) animal carrying capacity and d) soil fertility, leading to more production of wood and fodder. The technology is currently applied on a large-scale within the Niger River basin. As establishment of these systems requires high labor inputs, it makes them unattractive to farmers in Sahel, outside of donor financed projects (Ray and Simpson 2014).

## 4.10 Farmer Managed Natural Regeneration

As described by Pye-Smith (2013), the farmer managed natural regeneration (FMNR) or Régénération Naturelle Assistée (RNA) in French or *sassabin zamani* in Hausa, a local language in WAS, is a practice which involves identifying and protecting the wildlings of trees and shrubs on farmland. FMNR is a systematic regeneration of living stumps and emergent seedling of indigenous trees, which previously had been slashed and burned in field preparation. Most suitable are species with deep roots that do not compete with crops and have good growth performance even during poor rainy seasons. It depends on the existence of living root systems and seeds. Shoots from roots grow more rapidly than saplings from seed, and they make up the bulk of the protected woody matter on farms in southern Niger. Farmers will generally choose about five of the strongest stems from the stumps they wish to retain on their land, pruning away the remainder. These stems can periodically be harvested to provide firewood and timber. Farmers will often allow one stem to develop into a full-size tree. The species favored vary from place to place; as does the density of trees. Some projects have advised farmers to keep the number of trees at 40/ha, but densities of over 150/ha are not unusual. FMNR is a simple, low-cost method of re-vegetation, accessible to all farmers, and adapted keeping in mind the needs of smallholders. It reduces dependency on external inputs; is easy to practice and provides multiple benefits to people, livestock, crops and the environment. More broadly, FMNR represents a broad category of practices and thus does not adhere to specific, fixed technical aspects and suitability criteria. There are different FMNR practices for different agro climatic zones and farming systems (Liniger et al. 2011; Ray and Simpson 2014).

FMNR can be considered as an innovative successful agroforestry system, which made a significant impact, particularly in the Maradi region of Niger since yearly 1980s and ultimately covering more than 50,000 ha (Sendzimir et al., 2011; Haglund et al. 2011). Overall, the changes brought about by FNMR, including improved soil fertility and increased supply of food, fodder and firewood, have been estimated to be worth at least US$56/ ha each year (Holt and Legroscollard 2013). More farmers quickly adopted the practice, and from those first 95 villages, FMNR has now spread across southern Niger and even into neighboring countries, including Burkina Faso, Mali and Senegal. The success of FMNR has been widely documented. More than 5 million ha of land have been restored, with over 200 million trees re-established or planted in Niger (Rinaudo, 2007; Rinaudo, 2010; Pye-Smith 2013).

*Figure 5. Field cultivated with Farmer Managed Natural Regeneration of trees in Niger (Region of Maradi). Photo: Savadogo P*

## 4.11 Stone bunds - farmer natural regeneration

This innovative experience combines the stone bunds with FMNR. The system is newly identified only in Senegal (Kaffrine, Tabacounda, Villigara). But it seems to be interesting. The stone bunds could help improving the regeneration of trees.

### 4.12 Zaï technique

The Zaï or tassa holes technology and other RDL technologies are well documented (Roose et al. 1999; Mekdaschi Studer and Liniger 2013; Ray and Simpson 2014. Traditionally, planting pits were used on a small-scale to rehabilitate barren land (zipélé in Burkina) and hardpan areas where rainfall could no longer infiltrate. The promotion of Zaï became popular in the early 1980s in various location in WAS. They are dug by hand, with the excavated earth formed into a small ridge downslope of the pit for maximum capture of rainfall runoff. Manure is added to each pit before sowing (Figure 5). The improved infiltration and increased nutrient availability brings degraded land into cultivation. The technology does not require external inputs or heavy machinery and is therefore easily adopted. Zaï holes are often combined with stone lines along the contour to further enhance water infiltration, reduce soil erosion and siltation of the pits. Grass growing between the stones helps increase infiltration further and accelerates the accumulation of fertile sediment. Investigation on many fields of the Mossi Plateau (northern part of Burkina Faso) has shown a range of variations of the Zaï system in relation to soil texture, availability of labor and organic matter (Roose et al. 1999).

The Zaï can increase crop yields from 50% to 69% compared to untreated fields (Hien et al., 2015). After 2 to 7 years of a Zaï cropping system on a bare, crusted, degraded soil (eutropept), Roose et al. (1999) found that this system increased the production of both cereal grains (from 150 to 1,700 kg/ha) and straw (from 500 to 5,300 kg/ha), and also reintroduced a large diversity of useful plants (22 species of weeds and 13 species of forage shrubs) that may help the process of degraded soil restoration.

*Figure 5. The Zaï technique for restoration of degraded land. Photo: Hien and Fatondji*

But the main constraint of implementing this technique comes from the labor need to dig the holes. This operation is time consuming. While the performance improves with application of small doses of organic and/or mineral fertilizer, their availability is sometimes a constraint when livestock is not integrated in the system of farmers. Many research efforts to mechanize the digging of the holes with small tools by animal traction are on-going in Burkina and Niger. Some experiences in Niger showed that the time of implementation could reduce from 300 hours/ha with the manual system to 50 hours/ha with mechanized system (Hien et al., 2015).

The Zaï technology has been widely modified and adapted by farmers to the cropping systems in different countries. Two of them have been identified with different variants.

## 4.13 Zaï-Stone bunds

The Zaï-Stone bunds (ZSB) is an innovative experience developed by farmers. It is a combination of the two techniques: Zaï and Stone bunds. The goal is to take advantage of benefit from the two technologies to achieve: i) protection of soil against erosion, ii) rain water harvesting, iii) exploiting all advantages of zaï technologies in terms of better use of rain water, soil fertility improvement and iv) better management of the cropping system. This system is well known in Burkina and Niger. The system is particularly used in Niger in the region of Tahoua.

## 4.14 Zaï-Stone bunds-Farmer Managed Natural Regeneration

More than the Zaï-Stone bunds, this innovative experience adds framer assisted natural regeneration (FMNR). This experience is popular in central regions of Burkina, Senegal (Kaffrine, Tabacounda, Villigara), Mali (Kayes, Segou, Mopti) and Niger (Tahoua). The return on investment of this technique is estimated at 63% (Hien et al., 2015).

## 4.15 Semicircular bunds

As the name implies, semicircular bunds (SCB) (demi-lune or micro basin in Francophone West Africa), are earth embankments shaped in as a semi-circle, with the tips of the bunds facing uphill and aligned to the contour (Ray and Simpson 2014; Hien et al., 2015) (Figure 6). Semicircular bunds were initially developed to harvest the runoff water for growing crops. Organic residues (manure, compost) are locally applied in the SCB. The technique is used sometimes for establishing trees, rangeland rehabilitation and fodder production. Depending on the configuration of the chosen site, the technique may be deployed as a short slope or long slope catchment technique. Semicircular bunds are recommended as a quick and easy method of tree establishment and rangeland improvement in the semi-arid areas. The SCB is popularly used in Burkina, Mali, Niger and Senegal. The technique can increase crop yields by 112% (Hien et al., 2015). As for the Zaï technique, many systems of RDL have been developed using semicircular bands.

*Figure 6. Semicircular bunds for water harvesting and reduction of soil erosion. Photo: Fatondji*

## 4.16 Agroforestry-Semicircular bunds

As for the Zaï system, semicircular bands can be used to grow trees in the system. The improvement of humidity and soil fertility (manure or compost application) in the structure of SCB involves the germination of tree seedlings that coming from manure, compost or from winds. It is suggested to select and provide assistance to the selected tree seedlings. Then, the system contributes to reforestation. The system is well known in Burkina and Niger. Selecting and protecting the tree seedlings can be considered a kind of FMNR in the system.

### 4.17 Bio-reclamation of degraded lands

The bio-reclamation of degraded land (BDL) system has been developed by ICRISAT. It is an integrated system of RDL with different components, the semicircular bund (SCB) and Zaï structures, for food and vegetables crops and trees. The SCB are usually spaced at 5x10 m. The area between the SCB is occupied by planting pits of zaï. The vegetable crops are planted in the zaï holes, which also collects runoff water. Trenches are dug every 20 m down the slope to further harvest runoff water.

The BDL is an innovative production system of horticulture crops that provides solutions to a range of critical constraints affecting the livelihood of the rural population of the Sudano Sahel. Because of its simplicity and its many positive attributes, the potential for its mass-adoption is very high. The BDL is very popular in Niger. Because women have limited access to lands, many NGOs and projects are widely using the BDL systems as an alternative to rehabilitate the degraded lands for women associations.

*Figure 7. Regeneration of trees by the technique of Bio-reclamation. Photo: Fatondji*

### 4.18 Agroforestry parkland systems

The traditional agroforestry parkland system (APS) is the oldest system of the semi-arid and sub-humid zones of West Africa. The APS is more a sustainable management practice developed by farmers over years than a typical RDL technique. APS are cropland areas interspersed with self-generating, indigenous tree species. Farmers systematically protect a certain density of tree species of economic, social or medicinal interest. Among the characteristics of traditional agroforestry parklands are the diversity of tree species and the variety of products and uses (including fruits, fodder, etc.). *Vitellaria paradoxa, Parkia biglobosa,* and *Faidherbia albida* cereal systems are common across millions of hectares in the Sahelian zone (Breman and Kessler, 1997; Liniger et al. 2011; Ray and Simpson 2014).

## 5. Conclusion

The main goal of this review was to make an inventory of the technologies and experiences of RDL recorded in literature. Many technologies and practices of RDL have been developed and adapted by researchers in WAS. We identified 18 main systems of RDL with different variants. Some are developed from traditional practices. Most of the individual technologies or practices have been used to develop a diversity of systems of RDL. The diversity of the initiatives seems to be an indication of the dynamism of farmers, development agencies and researchers to improve the management, conservation and rehabilitation of degraded lands. The experiences are so diversified. Some interesting systems of RDL are very locally applied. The most efficient systems with significant impact are well documented, such as the success story of the farmer managed natural regeneration (FMNR) in Niger. But other systems are emerging combining different technologies including the FMNR. Some interesting systems, which no longer have significant impact, are fairly documented. Even though they have not yet made significant impact, some new innovations, locally adapted by farmers, need more attention. They are: i) Zaï+Stone bunds, ii) Zaï+Stone bunds+FMNR and iii) the agroforestry semicircular bunds (ASCB).

A next step is to visit all these experiences on the ground. Through field surveys, interaction with actors through focus group discussions, etc., should help in assessing the scope, the socio-economic context and opportunities to scaling the best experiences. This report and the working strategy will be shared for validation in a workshop involving all the stakeholders.

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