

Sustainable land management practices in the Sahel: review of practices, techniques and technologies for land restoration and strategy for up-scaling

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SUMMARY

Land conversion and degradation in the Sahel have emerged as a primary concern. The process leading to land conversion is sometimes as a consequence of multiple economic, social, cultural and political issues. These have seriously affected the ecological equilibrium, resulting in natural resources degradation, and hence a decline in agricultural production. With serious impact on peoples' livelihoods, climate change is also recognized as a major consequence of land conversion and threat in the region. Sustainable Land Management (SLM) is considered as a promising solution to land restoration, mitigation of climate change, and resilience of rural population to external shock. SLM is also considered as a tool for harmonisation of interventions between the major sub-sectors with respect to land use. The paper therefore reviews the various Sustainable Land Management (SLM) practices, techniques and technologies used in the Sahelian countries with focus on their suitability and biophysical benefits. Furthermore, the strategy for up-scaling of the land restoration practices in the Sahelian countries, as well as their requirements and barriers were discussed. Strategies to strengthen the capacities of all stakeholders in SLM approaches, practices, and techniques were recommended.

Keywords: sustainable land management, land restoration, Sahel region, forest resources, climate change

Pratiques de gestion durable des terres au Sahel : Revue des pratiques, techniques et technologies pour la restauration des terres et de stratégie de mise à échelle

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La conversion et la dégradation des terres sont des préoccupations majeures émergentes au Sahel. Le processus de la conversion des terres est parfois comme une conséquence de questions économiques, sociales, culturelles et politiques multiples. Celles-ci ont sérieusement affecté l'équilibre écologique, résultant à une dégradation des ressources naturelles, et donc une baisse de la production agricole. Avec de graves répercussions sur les moyens de subsistance et les conditions de vie des populations, le changement climatique est également reconnu comme une des principales conséquences de la menace et de la conversion des terres dans la région. La Gestion Durable des Terres (GDT) est considéré comme une solution prometteuse à la restauration des terres, à l'atténuation du changement climatique, et le renforcement de la résilience de la population rurale à des chocs externes. La GDT est également considérée comme un outil pour l'harmonisation des interventions entre les principaux sous-secteurs eu égard de l'utilisation des terres. Le document examine donc les diverses pratiques, techniques et technologies de Gestion Durable des Terres (GDT) utilisées dans les pays du Sahel avec un accent particulier sur leur pertinence et leurs avantages biophysiques. En outre, la stratégie de mise à l'échelle des pratiques de restauration des terres dans les pays du Sahel, ainsi que les besoins et les obstacles ont été discutés. Les stratégies visant à renforcer les capacités de tous les intervenants sur les approches, pratiques et techniques de la GDT ont été recommandées.

Prácticas sostenibles de gestión del suelo en el Sahel: revisión de prácticas, técnicas y tecnologías para la restauración de tierras y estrategia para extenderlas

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La conversión de tierras y la degradación en el Sahel se han convertido en una preocupación primordial. El proceso que conduce a la conversión de tierras es a veces una consecuencia de múltiples problemas económicos, sociales, culturales y políticos. Estos han afectado gravemente el

equilibrio ecológico, lo cuál ha causado la degradación de los recursos naturales, y por ende una disminución de la producción agrícola. Por su grave impacto en los medios de vida de las personas, el cambio climático se reconoce también como una de las principales consecuencias de la conversión de tierras y de las amenazas para la región. La Gestión Sostenible de Tierras (GST) se considera como una solución prometedora para la restauración de tierras, la mitigación del cambio climático, y la resiliencia de la población rural a las perturbaciones externas. La GST se considera también una herramienta para la armonización de las intervenciones entre los principales subsectores con respecto al uso del suelo. Por tanto, el artículo revisa las distintas prácticas, técnicas y tecnologías de GST utilizadas en los países del Sahel, con especial atención a su idoneidad y a los beneficios biofísicos. Además, se discute la estrategia para extender más ampliamente las prácticas de restauración de tierras en los países del Sahel, así como los requisitos y las barreras para ello. Se recomiendan estrategias para fortalecer las capacidades de todas las partes interesadas en los planteamientos, las prácticas, y las técnicas de GST.

BACKGROUND

The central role of forest to rural livelihoods has been emphasised (Salafsky and Wollenberg 2000, Belcher 2003, Warner 2003, Levang *et al.* 2005, Sunderlin *et al.* 2005, Shimizu 2006, Somorin 2010). Most poor people in Sahelian countries depend directly or indirectly on forests for their food security and livelihoods most especially in rural areas, hence, putting more pressure on natural resources with the constant increase in demand for forest products and other natural resources. The biological diversities within forests not only benefits people through more than just their contribution to material welfare and livelihoods, they also contribute to security, resilience, social relations, health, and freedom of choices and actions (MEA 2005, Ojea *et al.* 2010, Mercer *et al.* 2011). Forest vegetation also accounts for 75% of the living carbon apart from that in the soils (Corbera *et al.* 2010). As reported by FAO (2006), the total carbon content of forest ecosystems was estimated to be 638Gt in 2005. However, deforestation has been associated with reduction of carbon stocks in forests (Asner *et al.* 2005).

The Sahel region of Africa with about 50 million inhabitants is amongst the poorest regions in the world but has a rich forest resource (Table 1, Raynaut 1998). Forestry and agricultural sectors therefore provide employment for more than 60% of the active population of the region and also contribute 40% of its Gross Domestic Product (GDP) (Kandji *et al.* 2006). The dominant industries in the region are based in agriculture and livestock production, which mainly depends on rainfall. In Niger, forest resources contribute up to 9.5% of the GDP, and the economy relies largely on agro-silvo-pastoral production systems which contribute 40% to the GDP (SDR 2003). Furthermore, in the Sahel, forest resources serve as sources of raw materials for an array of non-wood forest products including crafting, roofing, medicine and other uses. However, over-exploitation of forest resources, overgrazing, desert encroachment, increasing population and aridity, and strong climatic variation and irregular rainfall are some of the challenges that have characterised the Sahel region of Africa (Larwanou 2011). There is therefore increasing concern that climate change effect on rainfall patterns, water availability and bushfire frequencies will have a severe consequence for rural livelihood and sustainable forest and environmental management in Africa and Sahel region in particular (Jenkins *et al.* 2002, Tyson *et al.* 2002, Martin *et al.* 2003, Challinor *et al.* 2007).

While forests are affected by climate change, they also play a key role in adaptation to climate change, for example, by increasing the resilience of rural communities (Kelly and Adger 2000). Forests support species to adapt to changing climate patterns and sudden climate events by providing refuge and migration corridors (Williams *et al.* 2005, Malhi *et al.* 2008). Forest and woodlands indirectly support economies to adapt to climate change by reducing the costs of climate-related negative impacts (Fankhauser 2013) through provision of goods and services during extreme events (droughts and floods). Forest ecosystems are therefore key assets for reducing vulnerability to the effects of climate change (Daily 2000, de Groot 2002). However, if the rate of forest exploitation and utilisation are not properly managed, this could serve as a source of greenhouse emission. On the other hand, contributions of forests and vegetation cover to climate change mitigation have been recognized as a cornerstone of the post-2012 climate change agenda with the decision on the reduction of emissions from deforestation and forest degradation (REDD+) (Okereke and Dooley 2010, Sukhdev *et al.* 2010, Sasaki and Yoshimoto 2010, Alexander *et al.* 2011, UNEP 2011a, 2011b, 2011c). The objectives of REDD+ include policy approaches and positive incentives on issues relating to reducing emissions from deforestation and forest degradation in developing countries and recognizes the contribution of conservation, sustainable management of forests and enhancement of forest carbon stocks (Corbera *et al.* 2010, UNEP 2011b). Developing appropriate adaptation and mitigation actions however include the improvement of forest management to reduce vulnerability and to mitigate GHG through REDD+ (Fry 2008, Levin *et al.* 2008, Blom *et al.* 2010, Corbera *et al.* 2010, Agrawal *et al.* 2011, Kanowskia *et al.* 2011). Several projects and programs to combat the impacts of climate change have been implemented by countries in the Sahel region particularly in rural areas. Some of these projects and programs involved desertification control, natural resources management, and the improvement of living conditions and income generation of the populations. At the technical and institutional levels, policies and strategies have been elaborated to strengthen commitment on implementing regional and global initiatives.

The objective of this paper is therefore to highlight measures that are being used by Sahelian countries to deal with various environmental and land degradation challenges. This is pertinent to understanding how this might interfere with

TABLE 1 Land resources in the Sahelian countries

| Country | Country area (km ²) | Population 2012 ^b | | | | GDP 2008 ^b | | | | Extent of Forest and other wooded Land area ^b | | | | Deforestation Rate (ha/yr) ^c |
|--------------|---------------------------------|------------------------------|----------------------------------|------------------------|--------------------|-------------------------|------------------------|----------|----------------|--|----------------|-----------------------|--------------------------|---|
| | | Total ^a | Density (inhbt/km ²) | Annual growth rate (%) | Rural (% of total) | Per capita (PPP) (US\$) | Annual growth rate (%) | Forest | | Other wooded land | | Other land (1 000 ha) | | |
| | | | | | | | | 1 000 ha | % of land area | 1 000 ha | % of land area | Total | of which with tree cover | |
| Burkina Faso | 274 200 | 15 275 115 | 56 | 2,61 | 81 | 1160 | 4,5 | 5 649 | 21 | 18 | 5 009 | 16 702 | 5 902 | -15 000 |
| Mali | 1 240 192 | 15 494 466 | 10 | 2,40 | 68 | 1129 | 5,0 | 12 490 | 10 | 7 | 8 227 | 101 302 | - | -99 000 |
| Mauritania | 1 030 700 | 3 359 185 | 3 | 3,10 | 59 | 2100 | 2,2 | 242 | n.s. | 3 | 3 060 | 99 768 | - | -10 000 |
| Niger | 1 267 000 | 16 344 687 | 12 | 3,36 | 84 | 683 | 9,5 | 1 204 | 1 | 3 | 3 440 | 122 026 | 8 000 | -62 000 |
| Nigeria | 923 768 | 170 123 740 | 166 | 2,55 | 52 | 2099 | 6,0 | 9 041 | 10 | 4 | 4 088 | 77 948 | 245 | -398 000 |
| Sénégal | 196 722 | 12 969 606 | 63 | 2,53 | 58 | 1793 | 3,3 | 8 473 | 44 | 26 | 4 911 | 5 869 | 1 174 | -45 000 |
| TOTAL | 4 932 582 | 183 093 346 | 229 | - | - | - | - | 17 514 | 54 | 30 | 8 999 | 83 817 | 15 321 | -629 000 |

^aCIA (2012) Estimate; ^bFAO (2010); ^cFAO (2006) cited in GGWI (2009).

emerging climate change challenge, and factors that need to be addressed to up-scale the most successful restoration practices and technologies in the region.

CLIMATE CHANGE, LAND CONVERSION AND FORESTS LOSS IN THE SAHEL

According to Mercer *et al.* (2011), forests can have impacts on climate change in two ways: increase global air temperature when they act as sources of emissions (through deforestation and forest degradation), or reduce global air temperature when they act as sinks (through removal of greenhouse gases from the atmosphere and subsequent storage in biomass and soil). It has been estimated that about 17.4% of global greenhouse gases (GHGs) emissions are derived from deforestation (Goers *et al.* 2012). Despite the global outcry on carbon emissions, the contribution of Africa to the global anthropogenic emissions has been discovered to be relatively small. In 1990, the continent contributed only about 7% of global greenhouse gas while 3.9% of the emissions were caused by the burning fossil fuels. However, the larger part of the emission (approximately 70%) from Africa was as a result of land-use change, especially deforestation (Karsenty *et al.* 2003). This then calls for concern due to the vital role of forests in the livelihoods of the people in Africa. With serious impacts on peoples' livelihoods, climate change is now recognized as a major threat to achieving the poverty reduction aspiration of many African countries as well as achieving the Millennium Development Goals (MDGs) (Mitchell and Tanner 2006). This condition is particularly worrisome for the countries in the Sahel region of Africa. A number of these countries are highly vulnerable due to their close proximity to the southern edge of the Sahara desert and the strong dependence of their population on forest resources, rain-fed agriculture and pastoralism (Kandji *et al.* 2006). Climate change is affecting rainfall patterns, water availability and sea level rise, thereby increasing droughts, floods and frequencies of bushfire. The impacts of these change in climate are many, some of which include adverse effects on human health, reduction of agricultural productivity and forest biodiversity (IPCC 2001, McMichael 2002, McMichael 2003, Endfield and Tejedo 2006, McMichael and Butler 2006, Dimes *et al.* 2008). The impacts of climate change have also been felt on household incomes as well as environmental resources on which the people depend (Allen and Breshears 1998, Millar and Woolfenden 1999, Dalea *et al.* 2000, Papadopol 2000, Spittlehouse and Stewart 2003, Guari and Taylor 2005, Aptroot and van Herk 2007, Millar *et al.* 2007, Lindner *et al.* 2010).

The loss of forests within the past few decades as a result of anthropogenic activities has been unprecedented and alarming (Lamb *et al.* 2005, Asner *et al.* 2005, Ojea *et al.* 2010). As at 2010, the updated estimate provided in the FAO (2010) in the Global Forest Resource Assessment put the world's total forest area to be just over 4 billion hectares while around 13 million hectares of forest were reported to have been converted to other uses – largely agriculture –

TABLE 2 *Rate of Forest Loss in Selected Sahelian Countries in Africa*

| Selected Sahel Countries | Rate of forest Loss (ha/yr) |
|--------------------------|-----------------------------|
| Burkina Faso | – 15,000 |
| Mali | – 99,000 |
| Mauritania | – 10,000 |
| Niger | – 62,000 |
| Nigeria | – 398,000 |
| Senegal | – 45,000 |
| Chad | – 82,000 |
| Sudan | – 956,000 |
| Ethiopia | – 40,000 |
| Eritrea | – 5,000 |
| Djibouti | — |

Sources: FAO (2006).

or lost through natural causes each year in the last decade. In the Sahel, land conversion and degradation has emerged as a primary concern. Land conversion stems from a wide range of social and economic processes that are highly variable in both space (between countries, and between ecological regions within countries) and in time (as economic and other drivers change). Forest are removed faster than the rate they are replaced, this is so because restoration is not carried out in the first place. Deforestation accounts for loss of more than 600 thousands hectares each year in the Sahelian countries (Table 2). Nigeria and Mali have the highest rate of deforestation, while Mauritania is having the least (FAO 2006).

Drivers of land conversion and forest loss

Actually, the processes leading to land conversion in Sahel may not be as simple as it sounds. It is sometimes as a consequence of multiple social, cultural and political issues. The countries of the Sahel have been facing a persistent lack of rainfall, combined with anthropogenic factors such as monoculture agriculture, bush fires, failure or lack of fertilization, grazing, among others. These have seriously affected the ecological equilibrium, resulting in the degradation of natural resources, soil and a decline in agricultural production. These are all indicators of an almost inexorable process of desertification and land degradation. The main identified drivers for land degradation in most Sahelian countries include:

- i. *Increases in population*: The population of the region, though predominantly rural (50 % to 80%), is characterized by a high growth rate of between 2.5% to 3.5%. In some countries, high growth rate ranged from 3.4% in Niger to 2.6% in Burkina Faso and 2.6% in Nigeria. The major issue with population growth is that it increases the pressure on forest and natural resources thereby directly contributing to land degradation and resource depletion. Farmers' traditional method of

clearing more land for crop production in response to population pressure is accelerating land conversion and degradation rate in the region. This has, in some instances, compelled farmers to use marginal lands for food production. Moreover, farmers' poor land management practices in the region, which have failed to adapt to changing environmental conditions and accelerated processes of erosion, are also found to be a major driver of land degradation (Larwanou and Saadou 2011).

- ii. *Expansion of economic activities dependent on natural resources*: the high poverty incidence in most Sahelian countries necessitates rapid economic development. To date, agriculture and especially livestock production is still the main driving force of the economy, providing the main source of income for the large majority of the people. For instance, the numbers of cattle, goat and sheep have strongly increased in the past 30 years from around 2 million in 1970 to around 8 million now in Burkina Faso. Also, the main cash crop, which is cotton, covered an area of 80,000 ha in 1970 while this area is of 500,000 in 2005.
- iii. *Climate change*: overall, rainfall in the Sahelian zone is erratic, with large variation between years. Rainfall patterns have been dominated by sequences of drier and wetter years. For instance, the 1970s and 1980s were particularly severe droughts in the Sahel, while rainfall in the years 1983 and 1984 were the lowest in the century. Nevertheless, since the mid-1980s, overall rainfall has gradually increased.
- iv. *Land ownership structure*: for a long-time land was managed by customary authorities. The recently introduced Agrarian and Land Reform Law largely rejected any role for customary authorities. The government was vested with the authority for the designation and retrieval of any piece of land. However, due to its complexity, this law was increasingly considered inappropriate with regard to customary rights and was strongly resisted by traditional leaders. In Burkina Faso for example, successive revisions of the legislation in 1991 and 1996 introduced the privatization of agricultural land under customary land tenure systems. The revision was envisaged at strengthening the security of resource tenure and increase agricultural productivity. While customary rights are formally recognized, no legal safeguards are provided for tenure security for most rural people and farmers are reluctant to take responsibility for the long term maintenance of soil fertility issues.
- v. *Traditional systems of pastoral areas*: this is characterized, to a large extent, by an open access and common property resources, of which the common management is guided by local traditions. Vitale and Lee (2005) reported that land use decisions of farmers or livestock-keepers are seldom the direct result of single driving forces. This enhances on one hand, the efficiency of the Sahelian pastoral system, as there is a strong spatial variability in annual rainfall, and thus allows pastoralists to lead their herds to the areas with

the most abundant animal feed resources. However, the system also stimulates the pastoralists to take as much grass resources as possible for their own herd resulting in overgrazing.

- vi. *Traditional system of forest resources management*: is also characterized by an open access and common property resources. The local stakeholders have few incentives to reduce the exploitation of fuel wood to a sustainable level in a state-owned forest. Recently, the introduction of forest and woodlands resources management by local communities to satisfy the demand of urban centres, has introduced the monetary value to wood – once free access and traditionally managed resource – to a commercial resource managed by local people based on sustainable management norms via rural wood markets. However, because of the monetary value attached to the business, the assigned wood cutters are no longer respecting the exploitation norms and this has led to unsustainable management of the meagre woodlands resources, most especially in Niger.

Other underlying drivers of land conversion and degradation in the Sahel region include loss of local know-how about soil conservation practices, and disappearance of services such as animal health, agricultural extension, supply of inputs and plant protection provided by the government. Such services were abandoned as a result of structural adjustment programmes. This challenge of land degradation experienced in most of the Sahel countries has induced a precarious situation of food security, energy supply and poverty (UA/CENSAD 2009).

Forest restoration and afforestation efforts in the Sahel

Putting a check to human actions on forest exploitation and utilisation is pertinent to support the continued flow of ecosystem services on which welfare of present and future generations depends (MEA 2005). To cope with these environmental challenges, efforts have been made at the technical, financial and institutional level to reduce the trends in which forests are being exploited with the aim of improving the livelihoods of populations through the implementation

of development projects. Some of the development projects implemented so far in Sahel include hydro-agricultural, reforestation to combating desertification, water management and the creation of national and sub-regional coordination. Table 3 shows the extent of forest regeneration in some Sahelian countries for both natural and planted forest area. Afforestation and natural regeneration of forests and woodlands in some countries have reduced the loss of forest area significantly at the global level. These efforts are certainly due to the application of Soil and Water Conservation practices conducted in most of the Sahelian countries. Sustainable management of forest and woodlands were advocated by some development projects in the nineteen eighties and nineties. However, despite these outcomes, it must be recognized that the results remain much below the expectations and the forest productive base has continued to deteriorate.

INTERVENTION BY INTERNATIONAL COOPERATIONS IN THE SAHEL

The wealth of the Sahel region depends on the ability to conserve and manage the land resources. Land degradation often leads to ecological imbalance, decreased food production and increasing levels of poverty which subsequently leads to degradation of quality of life (Gonzalez *et al.* 2012). It was reported that about 25% of families left their villages between 1975 and 1985 because of the droughts in the area covered by PATECORE, the German program in Burkina Faso. For these reasons, between 1980s and 1990s, many international cooperation, specially the German cooperation, provided support to people living in the Sahel for the development of technical, environmental, agricultural strategies and approaches for achieving the sustainable management of the environment and improving the quality of the different type of landscape units. This support, mainly in response to the humanitarian and environmental crises that brought severe famine and resulted in the loss of large areas of cropland, rangeland and forestland, focused on soil and water conservation (SWC) and soil protection and restoration (SPR) techniques (GiZ 2012).

Thus, some of the most important projects implemented in the Sahelian countries since 1980 have been on land

TABLE 3 *Forest regeneration in the Sahelian countries*

| Country/area | Other naturally regenerated forest | | | Planted Forest | | |
|--------------|------------------------------------|------------------|-------------------------|----------------|------------------|-------------------------|
| | 1 000 ha | % of forest area | % of introduced species | 1 000 ha | % of forest area | % of introduced species |
| Burkina Faso | 5 540 | 98 | – | 109 | 2 | 80 |
| Mauritania | 221 | 91 | – | 21 | 9 | – |
| Mali | 11 960 | 96 | 0 | 530 | 4 | 90 |
| Niger | 836 | 69 | 17 | 148 | 12 | – |
| Nigeria | 8 659 | 96 | 0 | 382 | 4 | 44 |
| Senegal | 6 456 | 76 | – | 464 | 5 | 53 |
| Total | 33 672 | – | – | 1 654 | – | – |

Source: FAO (2010).

improvement practices. The land development and resource conservation in Burkina Faso (PATECORE) has improved a total of 100,000 ha of land, mostly farmland, with contour stone bunds and permeable rock dikes and dams. In Niger, the Tahoua Rural Development Project (PDRT) focused on improving communal land on plateau, slopes and farmland, using contour stone bunds, zai planting pits, Nardi/Vallerani and hand dug trenches, semi-circular bunds and other techniques for over 125,000 ha and the PASP project over 500,000 ha. The Acacia Operation project improved the productivity of over 4,000 ha degraded agrosilvopastoral land (Maisharou 2007) using the Vallerani technology; while hundreds of thousands of hectares were rehabilitated by Keita Integrated Project. In Mali, the project for the rehabilitation of dams and tracks (PRBP) has led to construction of around 80 small-scale dams, and the Mali North program (PMN) improved around 13,000 ha of land with village irrigation schemes and measures for developing seasonally flooded depressions zones (GiZ 2012).

After decades of drought and famine, and following the Earth Summit held in Rio de Janeiro in 1992, most Sahelian countries have developed strategies and national action plan and program for combating desertification and the management of natural resource in order to meet the commitments undertaken by signing and ratifying Post-Rio international conventions, i.e. Conventions for Combating Desertification (CCD), Conserving of Biological Diversity (CBD) and the United Nations Framework Convention on Climate Change (UNFCCC) for mitigating climate change. Since then, the issues of environmental degradation including desertification and degradation of natural resources, such as forests, woodlands and trees have got special attention of international cooperation.

Implementation of Multilateral Environmental Agreements (MEAs) has enabled most of the Sahelian countries to make significant progress in the fight against desertification, environmental protection and the rehabilitation of degraded lands, forests and woodlands through various practices, techniques and technologies including farmers' assisted natural regeneration including soil protection and water conservation. Unfortunately, the results obtained so far remain insufficient given the magnitude of the phenomenon and the sectorial approaches that dominated the implementation of these plans and programs.

SUSTAINABLE LAND MANAGEMENT (SLM)

SLM practices and techniques in the Sahelian countries

With the launch of TerrAfrica process, Sustainable Land Management (SLM) concept was introduced and defined in 2005 as "the adoption of systems of land use, through appropriate management practices, to enable land users to maximize economic and social benefits of the land while maintaining and improving the ecological support functions of land resources". Since then, SLM concept is considered in most Sahelian countries as an imperative for sustainable

development and a tool for harmonization of interventions between the major sub-sectors of agriculture, livestock, water resources and the environment. It was unanimously accepted that SLM can promote cross-sector integration, as sought through the Agenda 21 and the Poverty Reduction Strategies elaborated and adopted by most of the Sahelian countries for achieving the Millennium Development Goals (MDGs).

The SLM practices and techniques are implemented in the field taking into account the objectives and the topography of the watershed units, which generally include plateau, slopes, pediments and valley bottoms. These topographical units have different types of soil, vegetation and uses and are often exploited by different groups of users under different forms of land tenure:

- i. *The plateau areas*: are communal lands with shallow, infertile, stony soils. Uses include grazing for livestock and the collection of wood, straw, fruits, bark and other secondary products. Land and vegetation on the plateau are often severely degraded due to overuse.
- ii. *The slopes*: also have shallow, stony soils with some grass and bush cover. Runoff water flowing over the plateau and steeper slopes hollows out gullies and causes landslides, which leads to serious degradation of the hillsides. These areas are of limited use as communal rangeland for livestock.
- iii. *The pediments*: are located in the piedmont areas of the plateau. They are gently sloping areas with deeper, more fertile soils. These are the main areas used for growing rain-fed crops. Plots are cultivated by individual farmers who grow food crops. The straw is used as forage for livestock in dry season. This type of land is prone to sheet and gully erosion caused by surface runoff flowing over the plateau and down the slopes.
- iv. *The valley bottoms*: have deep, more fertile soils enriched by fertilizing elements from upstream areas. Bottomlands are used to grow rain fed food crops during the rainy season. During the dry season, the shallow water tables are used to irrigate off-season cash crops. Plots of land in the valley bottoms are cultivated by individual farmers, although there are also sometimes communal grazing areas for livestock. The concentrated flow of water from upstream areas can lead to serious threat to bottomlands. Although it carries fertilizing sediment with it, it can also cause severe gully erosion and the siltation of land and other hydro-agricultural infrastructures.

There is no one-size-fits-all technical solution for the application of SLM practices and techniques. It is necessary to determine the most suitable practices and techniques in each case, taking into account the topography of land to be improved and the subsequent land uses. Therefore, an assessment of the watershed as a whole is made to choose a combination of techniques and practices adapted to the area's specific agro-ecological conditions (rainfall, topography, soil properties and structure, type of degradation, veg-

etation cover, etc.), which must also be feasible within the means of the farmers.

Many African countries have established framework with regard to the new sustainable Land management concept. A large diagnosis and assessment of practices, techniques as well as technologies have been carried out. Selected best practices could be scaled out/up for meeting the needs of environmental protection, poverty alleviation and the improvement of the local population's livelihoods. The most commonly used SLM practices, techniques and technologies in the Sahelian countries are summarized in Table 4.

Contributing factors to up-scaling land restoration in the Sahel

The historical success of many SLM projects of the 1980' and 1990' in the various countries of the Sahel were achieved mainly as a result of, among other things:

- i. *Sound organization*: the projects were initially organized in the form of 'autonomous' undertakings in collaboration with government bodies and the cooperation agencies. Most of the activities were carried out by project staff who had sizeable logistics units at their disposal and their own equipment and means of transport;
- ii. *Clearly identified intervention unit*: the village land area was the basic unit for interventions, which were based on a simplified spatial planning approach and land management organizations. As time went on, the projects worked increasingly with local providers (carriers, consultancy firms, NGOs) to carry out part of the work and involved the commune authorities in planning and monitoring the measures implemented;
- iii. *Participatory approaches*: implication of the beneficiaries after intense sensitizing campaigns and training of the local people.
- iv. *Substantial financial support*: A lot of money and time were needed for achieving successful impacts on SLM practices. The Keita Integrated Project in the Republic of Niger financed by the Italian Government has achieved tremendous results as a result of many phases from 1984 to 1998 in the same areas and has spent billions of FCFA.

In order to consolidate the results achieved at the cost of sustained efforts of over 40 years of degraded lands rehabilitation, sand dunes stabilization, and the management of their meagre forest and woodlands resources, most Sahelian countries joined the international platform of TerrAfrica. Since then, with the support of TerrAfrica Platform, coalition partners such as UNDP, World Bank, IFAD, FAO, NEPAD, UNCCD-Secretariat, UNEP, ADB, GEF, among others have also been involved. Most of these countries have established a programmatic approach to the sustainable management of land, forests and woodlands and agreed on roadmap for the formulation of a Strategic Investment Framework for Sustainable Land Management (SIF-SLM).

As a platform for dialogue and consultation, TerrAfrica supports African countries south of the Sahara to achieve their goal through an open and inclusive partnership. Up to date, most of the Sahelian countries have elaborated their SIF-SLM. The opportunities and the conditions for amplifying, up-scaling and streaming the best SLM practices which differ from one country to another are also identified by most countries. The results of these large national consultations among the stakeholders from various countries of the Sahel are summarized in Table 5.

Considerations for implementation of SLM practices, techniques and technologies

It is now widely accepted that SLM practices provide an effective way of improving the management of water resources and the reduction of soil, vegetation and biodiversity degradation, which helps to increase and maintain crop, forest and forage yields. SLM practices application could contribute to mitigating the effects of climate change and significantly improve food security and the resilience of the rural population to external shocks. The implementation of the SLM practices, techniques and technologies is therefore a promising solution for countries in the Sahel. Their wide scale implementation requires long-term commitment and huge financial resources in order to achieve significant impacts.

Large scale implementation of SLM practices also requires sustained national and international technical and financial efforts on the part of governments to ensure effective community organization and oversee the efforts of communities to implement, operate and maintain these practices. Without the sustained technical oversight and guidance, the implementation of SLM techniques and practices will lose momentum, because in most cases, the traditional short-term projects can only contribute to a specific investment in the broader land improvement framework, with no significant results.

Although there exists simple and low or no cost SLM practices and techniques such as Zaï, semi-circular bunds and Farmers Managed Natural Regeneration that could be easily replicated by farmers, their large scale application has been hindered by the failure of farmers to take the initiative and replicate them by themselves, not because of lack of knowledge and expertise, but because of lack of incentives, as it is familiar in most SLM projects and programmes. Hence, to achieve the objectives of large scale implementation of best SLM practices, techniques and technologies, several hypotheses could be taken into account in the formulation of sound recommendations and these are:

- i. The use of the food for work approach by some of the projects provides an incentive by enabling people to generate income while implementing the SLM practices, but it also has a demobilizing effect when the farmers have to continue the activities on their own after external funding has come to an end;
- ii. Farmers may be deterred from making long-term investments in such practices by the fact that they have

TABLE 4 Common SLM practices in the Sahelian countries

| Common SLM practice | Description | Suitability | Biophysical benefits | Reference | Countries where practised |
|---------------------------------|--|--|---|--|---|
| Semi-circular bunds / Half moon | Involves building low embankments with compacted earth or stones in the form of a semi-circle (<i> demi-lune </i>) with the opening perpendicular to the runoff and arranged in staggered rows. | For rangeland improvement and fodder production in arid and semi-arid regions where rainfall range is 200 - 750 mm; soils are neither shallow nor saline; and slopes are below 2%. Semi-circular bunds can be designed to a variety of dimensions; A common technique is to design the bunds to have 6 metre radii. This design is suitable for slopes of 1% or less, consists of a series of small semi-circular bunds with radii of 6 metres. Each bund has a constant cross section over the whole length of 19 m. The recommended bund height is 25 cm with side slopes of 1:1 which result in a base width of 75 cm at a selected top width of 25 cm. | This is particularly advantageous when rain is scarce. They slow down runoff and enable the harvested water to be used. They are used to rehabilitate degraded, denuded and hardened land for crop growing, grazing or forestry. | Critchley <i>et al.</i> 1991, Barrow 2014 | Burkina Faso, Mali, Mauritania, Niger, Nigeria, Senegal |
| Nardi / Vallerani trenches | They are made using a tractor-pulled plough called Delfino specifically designed for this purpose. The Nardi plough cuts a furrow perpendicular to the slope, throwing up a ridge on the downhill side and thereby creating a barrier on that side of the furrow. | Recommended number of micro catchments for flat or gently sloping terrain is between 250 and 400 per hectare, with the rows spaced 5 to 7 m apart; and for steeper slopes, the rows should be spaced 3 to 4 m apart, with a density of up to 600 micro catchments per hectare. | Effective in low rainfall situation, as the micro catchments collect the little rainfall water making available to the plants growing in them. Can extend and improve the quality of forest and rangeland and the quantity of pasture during years of droughts. | Drechsel <i>et al.</i> 2005, Doriöchter-Sulser and Nill 2012 | Burkina Faso, Mali, Mauritania, Niger, Nigeria, Senegal |
| Trenches | The technique involves manually excavation of trenches. The main purpose of this technique is to restore tree cover and prevent water erosion on slopes by reducing the flow of water that threatens land downstream. | Trenches could be between 3 to 3.5m long and 0.6m deep, spaced 4m apart in staggered rows, giving average number of 625 trenches per hectare. | The trenches reduce gully erosion and sedimentation of areas with a fragile soil structure. Increase in plant density of 300 plants/ha have been reported. | Vecchia <i>et al.</i> 2005 | Burkina Faso, Mali, Niger, Nigeria, Senegal |
| Contour bunds | These are either for crop production, or for forest and rangeland protection. It's a rectangular structure consisting of bunds built with earth or stone or a combination of both, which can be permeable or impermeable. The contour bunds are built in staggered rows along the natural contour of the land with the open end facing uphill. | The bunds for crop production could be up to 80 m long with wings extend up to 15 m upslope and spaced 10 – 25m apart, while that of forest or rangeland the bund could be up 100 m long, wings 15 m and spaced 30 m apart. In the down slope face of the bund, a water collection ditch 1.00 m wide and 0.50 m deep is dug. | Contour bunds are very effective technique in areas of rainfall, as they increase the amount of water available to crops and vegetation. In case of areas of heavy rainfall, the number of bunds per hectare could be increased to retain the maximum of runoff and avoid the destruction of bunds. | Doriöchter-Sulser and Nill 2012, Doriöchter-Sulser and Nill 2012, Abdou 2014 | Nigeria |

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|----------------------|---|---|--|---|---|
| Contour stone bunds | Contour stone bunds are erosion control techniques built with stones in series of two or three stones. The best results are achieved when contour stone bunds are used in combination with biological measures (planting of grass, trees and hedges) and the use of organic fertilizer and mulching. | They are constructed in lines along the natural contour of the land after 10–15 cm of the soil has been removed from the line where they are to be built. They should be built to a height of 20–30 cm from the ground and spaced 20 to 50 m apart depending on the inclination of the terrain. | They improve water retention and infiltration into the soil, increasing the amount of water available to plants and guaranteeing good harvest. Also provide protection against wind erosion in case of good growth of vegetation cover. | Critchley <i>et al.</i> 1991, Dorlöchter-Sulser and Niil 2012, Abdou 2014 | Niger, Burkinafaso, Mali, Mauritania, Senegal, Nigeria |
| Zai / Tassa | Zai / tassa (water pocket) is a traditional practice developed by Sahelian farmers. It involves digging planting pits with staggered rows of holes dug perpendicularly to the slope. The excavated earth is formed into a small ridge down slope of the pit for maximum back capture of rainfall and runoff. | It consists of digging pits with diameter of 30cm and between 0.10–0.25 m deep. Hence filling with mixed 500g of organic manure and soil up to 10 cm deep. Two handfuls of organic amendment such as crop residues, manure or their composted form are then placed in the pits. | Zai pit is a water harvesting technique which help to better hold water for crop millet and avoid loss of organic manure by runoff. Zai pit has the advantage to allow sowing crop even during low rainfall. The improved infiltration and increased nutrient availability brings degraded land into cultivation. Have been successfully used to attain increase and yield in growing Millet in Niger. | Barry <i>et al.</i> 2008, Dorlöchter-Sulser and Niil 2012 | Burkina Faso, Mali, Niger, Nigeria, Senegal |
| Benches / banquettes | It's a rain multiplier that uses part of the land surface as a catchment to provide additional run-off onto level terraces on which crops are grown. | Suitable for reclamation of plateau and abandoned land in the valleys for agricultural and pastoral purposes | Effective in reclaiming arable land previously subjected to desertification and abandoned. Used to grow crops such as Millet, and sorghum. | Hudson 1987, Vecchia <i>et al.</i> 2005, Vecchia <i>et al.</i> 2007 | Burkina Faso, Mali, Niger, Nigeria, Senegal |
| Sub-soiling | Sub soiling is the process of deep tilling of the ground (12"-18" deep). It is mainly used to uncompact the soil, but it also improves aeration of the soil and dispersion of nutrients. It originally got its name because top soil is usually only 6" deep at the most then below that is the sub soil. To till deeper than 6" would incorporate the subsoil with the top soil. | Sub-soiling technique also known as deep tillage involves breaking up soil 12–18 inches deep, in order to allow increased water movement, better aeration of the roots and access to additional minerals and nutrients for plant growth. | One of the attractive features of this technique is the ability for a farmer to practice no-till which helps to conserve and improves water quality and stores more carbon in the soil than tilled land. Improved corn and soybean yields. | AG Answers 2005, Raper and Bergtold 2007, Kees 2008 | Burkina Faso, Mali, Niger, Nigeria, Senegal |
| Mulching | Mulching is an old technique used to improve soil conditions by spreading of plant materials (straw, stalk, leaves, etc), or other waste, over cultivated or areas planned to be cultivated. | The amount required varies from 2 t/ha every year to 6 t/ha every 3 years, depending on the condition of the soil and the availability of manure and compost. | Facilitate soil conservation and maintenance of soil fertility. The use of compost and manure improves crop yields and outputs. Confirmed to be effective when rainfall is inadequate. Straw does not add significantly to soil nutrients, but does improve humidity. | Hien 1998, Lamers <i>et al.</i> 1998, Dorlöchter-Sulser and Niil 2012 | Burkina Faso, Mali, Mauritania, Niger, Nigeria, Senegal |

(Continued)

TABLE 4 (Continued)

| Common SLM practice | Description | Suitability | Biophysical benefits | Reference | Countries where practised |
|----------------------|---|--|---|--|---|
| Composting | Compost is a form of organic fertilizer made by piling vegetable matter into a heap (compost heap) and then allows decaying. | The soils of the Sahelian zone, typically contains low content of active clay which makes soil organic matter management a key element. Materials needed to make compost include plant materials (dry and green), water, animal materials (dung, droppings, urine, etc), soil-organisms (fungi, bacteria, worms, etc), air and heat. The materials are either allowed to decay in a pit or as or above the ground through the action of micro-organisms in soil. | Use to improve management of soil organic matter, alleviation of soil degradation, helps the soil hold both water and air for plants, and improvement of crop production in the Sahelian zones. It brings plants a source of nutrients (NPK, and micronutrients) which can be rapidly assimilated. | Thiam 1988, Rahman 2009, Edwards and Araya 2011. | Burkina Faso, Mali, Mauritania, Niger, Nigeria, Senegal |
| Permeable rock dams | 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 3 meters 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. | Used the period of low or high rainfall. By dissipating the flow of floodwaters, they ensure better use of rainwater and are therefore important in dry periods. By slowing the flow of rain water, the permeable rock dams also contribute to reducing of gully erosion in wet periods when there are violent downpours. They also protect the land around water ways, restore and increase the area of land that can be cultivated. | Doriöchter-Sulser and Nill 2012 | Burkina Faso, Mali, Mauritania, Niger, Nigeria, Senegal |
| Permeable rock dikes | Permeable rock dikes are erosion control technologies built along the natural contour of the land. They are made with different-sized of stones and rocks. There are two main types of permeable rock dike: the permeable non-filtered layer dike established on suitable flat land with no gully erosion and the permeable filtered layer dike suited to land with heavy runoff. | They are built with 30 to 50 cm high and 60 to 100 cm high. | During period of heavy rain and violent downpours, they dikes protect land from erosion, improve infiltration during dry period with little or no rainfall thereby increasing availability of water to crops. | Doriöchter-Sulser and Nill 2012 | Burkina Faso, Mali, Mauritania, Niger, Nigeria, Senegal |

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|--|--|--|---|--|---|
| Farmer Managed Natural Regeneration (FMNR) / RNA | Farmer Managed Natural Regeneration (FMNR) is the systematic regeneration of living tree stumps in the fields to be re-vegetated. Desired tree stumps are selected. For each stump, a decision is made as to how many stems will be chosen for growth. The tallest and straightest stems are selected and side branches removed to roughly half the height of the stem. The remaining stems are then culled. Returning regularly to prune any unwanted new stems and side branches attains best results. | FMNR is especially applicable, but not restricted to, the drylands tropics. It can be used to return degraded croplands and grazing lands to productivity. It can also play an important role in maintaining not-yet-degraded landscapes in a productive state, especially when combined with other sustainable land management practices. | The techniques enable farmers to protect and manage the regeneration of native trees and shrubs among their crops. Farmers adopt it to increase their resilience to climate change impacts by restoring their land leading to better cereal yields as well as new alternative livelihoods including NWFP such as fuel wood, fodder, and edible fruits and leaves. | WRI 2008, Larwanou, Abdoulaye, and Reij 2006 and Larwanou and Adam 2008. | Burkina Faso, Mali, Mauritania, Niger, Nigeria, Senegal |
| Windbreaks / hedgerows | Windbreaks are narrow strips of trees, shrubs and/or grasses planted to protect fields, homes, canals, and other areas from the wind and blowing sand. Shelterbelt, on its own is a type of windbreak, long, multiple rows of trees and shrubs, usually along sea coasts, to protect agricultural fields from inundation by tidal waves. | Windbreaks usually consist of multistory strips of trees and shrubs planted at least three rows deep. They are placed on the windward side of the land to be protected, and are most effective when oriented at right angles to the prevailing winds. They are common 100 m long or more, with a peak height of 10 m. | Windbreak reduces the velocity of the wind, improves the microclimate by decreasing water evaporation from the soil and plants, protect crops from loss of flowers as well as reduce crop loss due to sand-shear of seedlings, and increase the productivity of the crops they protect. | Vandenbeidt 1990, Nair 1993, Lamers <i>et al.</i> 1994 | Burkina Faso, Mali, Mauritania, Niger, Nigeria, Senegal |
| Intercropping/ Mix cropping | Intercropping, or mix cropping, is the cultivation of two or more crops at the same time (simultaneously) in the same field. At least four basic spatial arrangements are used in intercropping: row, strip, mixed and relay. | When two or more crops are grown together, each must have adequate space to maximize cooperation and minimize competition between the crops. To accomplish this, four things must be considered: 1) spatial arrangement, 2) plant density, 3) maturity dates of the crops, and 4) plant architecture. | Intercropping allows for better utilization of growth resources, and improve and stabilize yields therefore constitute a risk avoidance practice in a rain-fed production system. It can also reduce the effect of insects and weeds, and increase nitrogen content in the soil. Usually, legume and cereal seeds are mixed and sown in the same pit but this practice increases competition between species. | Nair 1993, Bayala <i>et al.</i> 2011 | Burkina Faso, Mali, Mauritania, Niger, Nigeria, Senegal |

(Continued)

TABLE 4 (Continued)

| Common SLM practice | Description | Suitability | Biophysical benefits | Reference | Countries where practised |
|-------------------------|---|--|---|----------------------|---|
| Sand dune stabilization | This is the use of living or non-living materials to stabilize the moving sand; improve the properties of sand dunes and enhance the productivity of crops. Some of the techniques used for sand dune stabilisation include the use of plastic sheets, plant residues, and planting of natural wind breaks/shelter belts. | 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 or tree materials or by hedges and trees such as <i>Leptadenia pyrotechnica</i> , <i>Euphorbia balsamifera</i> , <i>Acacia raddiana</i> , <i>Acacia senegal</i> , <i>Balanites aegyptiaca</i> , <i>Prosopis juliflora</i> , etc. | They provide protection from wind erosion and reduce the amount of sand blown onto cropland, dwellings and other infrastructure. Grass and shrubs are planted in strips in the fenced areas which must be protected for at least three years prohibiting all forms of uses. | FAO 2012 | Burkina Faso, Mali, Mauritania, Niger, Nigeria, Senegal |
| Fire breaks | A firebreak is a gap in vegetation that acts as a barrier to slow or stop the progress of a bushfire or wildfire. | Firebreaks could be created manually or mechanically. In both cases, 10 to 15 m wide pathways are cleared perpendicular to the prevailing wind direction after the rainy season. | Firebreaks are precautionary measures designed to control fire in agroforestry systems or protect pasture on rangelands during the dry season when winds are very frequent. In the high Niger Valley, early fires are used to stimulate fruit production in Vitellaria if it stops bearing fruit for two to four years. Similarly, fire had a positive effect on flowering in the Bassila region of Benin. | Boffa 1999 | Burkina Faso, Mali, Mauritania, Niger, Nigeria, Senegal |
| Direct seeding | Direct seeding is the sowing of seeds directly in the soil, by-passing the need for nurseries and irrigation. | Direct sowing of seeds on the field without planting in the nursery beds or poly pots. Direct seeded perennials tend to produce an extensive root system rapidly than those raised in the nursery, and able to tolerate drought. | Direct sowing is beneficial in producing food and conserving water, nutrients, etc. it has been successfully used in re-vegetation of arid land and stabilization of degraded land through direct seeding. | Eden foundation 1996 | Burkina Faso, Mali, Mauritania, Niger, Nigeria, Senegal |
| Aerial seeding | Aerial seeding is considered a broadcast method of seeding. This technique is often used to broadcast different grasses and cover crops like legumes to large areas of lands. | Aerial seeding is an alternative to other seeding methods where terrain is extremely rocky or at high elevations or otherwise inaccessible | The aerial seeding method is advantageous for large sparsely populated areas in the Sahel where a sparse human population makes the planting of seedlings by hand a difficult proposition. Example of successful planted species include Sudan grass, perennial Rye, hairy vetch etc. A number of good fuelwood and plantation species have been sown successfully from the air, including <i>Eucalyptus camaldulensis</i> ; <i>Leucaena leucocephala</i> | Ayensu 1983 | Mauritania, Nigeria |

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|------------------------|---|--|---|---|----------------|
| Minimum / Zero tillage | <p>Also known as no-till irrigation farming. It is a way of growing crops or pasture from year to year without disturbing the soil through tillage.</p> | <p>The goal of minimum tillage is to reduce soil manipulation necessary for a successful crop production. It is a tillage method that does not turn the soil over. It is contrary to intensive tillage, which changes the soil structure by ploughs.</p> | <p>No-tillage is beneficial in improving soil biological fertility, thereby making soils more resilient. It has been successfully used in the Sahel to grow crops such as cotton, sorghum, sunflower, tomatoes and legumes. In using this technique the fields are weeded by hand.</p> | <p>Gritzner 1981, Barbara 2009</p> | <p>Nigeria</p> |
| Cover cropping | <p>A cover crop is a crop planted primarily to manage soil fertility, soil quality, water, weeds, pests, diseases, biodiversity and wildlife in an <i>agro-ecosystem</i>. There are many different types of cover crops. Most are either grasses (such as rye, barley, and oats) or legumes (clover, peas, beans, and vetch). Legumes are unique in their ability to fix nitrogen in the soil.</p> | <p>Farmers choose to grow and manage specific cover crop types based on their own needs and goals, influenced by the biological, environmental, social, cultural, and economic factors of the food system in which farmers operate.</p> | <p>In addition to helping bulk up soil with organic matter, cover crops prevent erosion, suppress weeds, and create and cycle soil borne nutrients using the power of the sun. Cover crop (<i>Mucuna</i> sp) in western Burkina Faso (K. Traoré)</p> | <p>Lu <i>et al.</i> 2000, Snapp <i>et al.</i> 2005, Barbara 2009</p> | <p>Nigeria</p> |
| Improved fallow | <p>The term fallow is used to refer to a period that agricultural land is lying idle, or to 'resting period' to regain its fertility. Improved fallow means to grow something on the land that will improve the soil faster than the traditional fallow.</p> | <p>This technique entails growing of selected fallow species without crops for a short period of time. Whereas traditional fallow may require a fallow period of 10 to 20 years, fast growing nitrogen-fixing trees or shrubs are grown for one to three years under improved fallow to raise the soil fertility in short period of time. Selective cutting and weeding of the natural vegetation, and in some instances, replacement of natural vegetation with trees or herbaceous plants that occurs in improved fallow distinctly differentiates it from natural fallow.</p> | <p>Improved fallow provides both economical and biological benefit. Economic benefits results through increase in the economic utility of the fallow (its direct products). Biological benefit results from acceleration of the regeneration of soil fertility and the control of weed.</p> | <p>Nair 1993, Place and Dewees 1999, Sanchez 1999</p> | <p>Nigeria</p> |
| Contour ploughing | <p>Contour ploughing (or contour farming) is the farming practice of ploughing and/or planting across a slope following its elevation contour lines. These contour lines create a water break which reduces the formation of rills and gullies during times of heavy water run-off; which is a major cause of top soil loss and soil erosion.</p> | <p>The practice is effective only on slopes with between 2% and 10% gradient and when rainfall does not exceed a certain amount within a certain period. Contour ploughing are difficult to combine with conservation agriculture (ploughing along the contour) because it often entails disturbing the soil and removing the soil cover</p> | <p>The technique prevents tillage erosion. It has been used to rehabilitate thousands of hectares of degraded lands, and improved efficient use of water resources in the Sahel.</p> | <p>Van Oost <i>et al.</i> 2006, Reij <i>et al.</i> 2009, Wikipedia 2014</p> | <p>Nigeria</p> |

TABLE 5 Requirements for up-scaling SLM practices in the Sahelian Countries

| Country | Major issues | Barriers to SLM up-scaling | Requirements for up-scaling |
|---------------------|---|---|--|
| Burkina Faso | <ul style="list-style-type: none"> - High population growth - High demand on natural resources - Insecure land tenure - Increase agricultural land degradation - Degradation of pasture lands - High deforestation rate | <ul style="list-style-type: none"> - Increase population growth - Expansion of economic activities depending on natural resource - High degradation on natural resources due to climate change - Insecure land ownership - Traditional systems of pasture and forest resources management - Insufficient resources allocation | <ul style="list-style-type: none"> - Mainstreaming SLM practices in all developmental sectors - Train and support local population - Capitalize past experiences on Community land management - Support agricultural diversification - Train farmers through Farmer Field Schools - Secure land arrangement - Enhance institutional support - Enhance micro-credit support in economic activities - Enhance monitoring the use of natural resource - Enhance capacity building of local population - Enhance afforestation/reforestation through mobilization of CDM finances |
| Mali | <ul style="list-style-type: none"> - Land degradation - Loss of biodiversity - Degradation of agro ecosystems - Rivers siltation - Sand dunes encroachment on farm lands and other socioeconomic infrastructure - Frequent bush fires - Depletion of surface and ground water | <ul style="list-style-type: none"> - Sectoral approaches to SLM application - Unsecure land tenure - Lack of financial resources - Lack of technological knowhow and knowledge - High population growth rate - High pressure on natural resources | <ul style="list-style-type: none"> - Mainstreaming SLM practices in all developmental sectors - Mobilization of adequate financial resources - Improvement of institutional capacities of the National Council for Environment - Enhancing the legislative and regulatory environment for SLM application - Enhancing the advisory role of technical service - Improving the participation of private sector in SLM practices - Harmonization of planning - Development of data collection and decision making tools - Implementation of sound communication strategy - Capacity building of all stakeholders |
| Mauritania | <ul style="list-style-type: none"> - Promote the growth of production sectors - Ensure equitable access to land resources - Increase supply and availability of goods and service for sustainable development - Development of stakeholders management capacities | <ul style="list-style-type: none"> - Lack of accurate knowledge of land degradation - Plurality whose activities impact SLM - Plurality of institutions in charge of SLM practices coordination - Insufficient financial resource allocation | <ul style="list-style-type: none"> - Improvement of the quality of information on SLM - Capitalization of the existing knowledge - Improvement of knowledge on land resources - Strengthening the capacities of SLM multi-sectors and improvement of synergies - Mainstreaming SLM practices in all developmental sectors - Integrating SLM teaching in higher education - Mobilization of adequate financial resources for SLM amplification - Improvement of SLM monitoring and coordination of SIF-SLM - Improvement of pasture through aerial seeding - Control of agricultural land salinity - Control sand encroachment on infrastructures - Development of wetlands |
| Niger | <ul style="list-style-type: none"> - Soil infertility in crop lands - Degradation of farm lands especially hardpan - Degradation of pasture lands: proliferation of non-palatable species - Biodiversity loss - Degradation of forest and wood lands - Silting of water bodies - Sand dunes encroachment | <ul style="list-style-type: none"> - Unsecure land tenure - Lack of financial resources - Lack of technological knowhow and knowledge - Sectoral approaches to SLM application | <ul style="list-style-type: none"> - Harmonization of field intervention - Mainstreaming SLM practices in all developmental sectors - Development of advocacy and information on SLM - Increase experience sharing among farmers - Development of decision making tools - Strengthening political dialogue - Improvement coordination - Improvement of monitoring and evaluation - Provision and mobilization of adequate national financial resources - Improved planning and coordination in the external financial assistance |

TABLE 5 (Continued)

| Country | Major issues | Barriers to SLM up-scaling | Requirements for up-scaling |
|----------------|--|---|---|
| Nigeria | <ul style="list-style-type: none"> - Overgrazing - Overexploitation of natural resources - Food insecurity - Irrigation malpractices - Intensive exploitation of forest resources - Loss of biodiversity - Land use conflicts | <ul style="list-style-type: none"> - Lack of detailed knowledge on SLM practices - Fragmented institutional coordination capacities, mandates and policy - Inadequate access to information and knowledge to producers | <ul style="list-style-type: none"> - Mainstreaming SLM practices in all developmental sectors - Capacity building, Communication and information dissemination - Monitoring, evaluation, Coordination, knowledge and information management |
| Senegal | <ul style="list-style-type: none"> - Increase land degradation - Loss of biodiversity - Increase flooding - Reduction of forest resources - Degradation of wildlife habitat - Increase poaching and reduction of wild animal - Invasion of water bodies with unwanted species - Reduction of fish production - Lack of specific legal framework for risk management | <ul style="list-style-type: none"> - Inadequate resource allocation - Weak scientific result application - Lack of advocacy and sensitization - Weak institutional framework - Various institution in charge of SLM with different views | <ul style="list-style-type: none"> - Mainstreaming SLM practices in all developmental sectors - Amplification of identified best SLM practices - Strengthening agricultural advisory services - Support to producers organizations and their functioning - Strengthening the inter-sectoral coordination of SLM implementation - Strengthening the technical and financial coordination of the SLM practices application - Strengthening the monitoring and evaluation of SLM projects |

Source: Abdou (2014).

- other immediate needs to meet and that land rights are not guaranteed;
- iii. The technical complexity of some SLM practices and techniques are beyond the capacities of the producers and require external support for their application. These include permeable rock dams, water-spreading weirs and small-scale dams;
 - iv. The SLM practices application requires large-scale logistics and financial resources. Their large scale application is not easy to organize without the support of a project or external partner. This is the case of practices involving the transportation of large blocks of stone from quarries located at a distance from the site or the purchase of cement such as water-spreading weirs;
 - v. The complexity of social relations can hinder the implementation of SLM practices amplification: working together to improve communal sites is no easy feat. Community organization entails the risk of disputes and conflicts and requires capable local leadership. Experience has shown that practices implemented on individually owned land are more sustainable and more easily replicable than those implemented on communal land;

- vi. The allocation of limited resources, such as family help to carry out the work is another factor to be taken into account. Using family members to implement SLM practices in the villages may be less profitable than allowing them to emigrate to work in urban centres;
- vii. In view of the rapid and relentless pace of land degradation and the fact that most farmers cannot afford to invest in SLM practices by themselves, provision should be made to make funding available from the government and the international community for this purpose. This would allow the implementation of SLM practices on a wider scale. Private Service providers and NGOs could be commissioned to implement SLM practices under the technical supervision of government authorities.

CONCLUSIONS AND RECOMMENDATIONS

The review shows that there are a number successful SLM practises that have been developed and adopted in the Sahel. However, these have not been scaled-up for wider adoption due to a number of limiting factors including, chief among them, the lack of enabling environment such as the improve-

ment of institutional, political and financial capacities. Another factor that was highlighted as a barrier to up-scaling was poor extension and monitoring mechanisms for up-scaling of low cost SLM practices such as farmers managed natural regeneration and Zaï, practises due to lack of financing and capacity of civil society, private sector, local authorities, and public sector organizations at all levels.

Therefore it is recommended that the SLM practices should be integrated into the multi-sectoral policy frameworks in the region since SLM programmes are usually cross-sectoral in nature. In addition, there should be adequate funding through both internal and external resource mobilization for up-scaling the SLM practices, techniques and technologies which are beyond the capacities of local communities; such as water harvesting technologies, soil fertility improvement techniques, afforestation and management of forests and protected areas, among others. Furthermore, there is need to improve the advisory roles of the technical services especially the participation of the private sector in the implementation of best SLM practices, techniques and technologies through the development of harmonized planning and promoting marketable goods and service derived from the implementation of SLM practices.

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