Water and soil conservation practices in the Sahel: an analysis of their potential to increase resilience of rural livelihoods

ACKERMANN, Klaus\textsuperscript{a}, NILL, Dieter\textsuperscript{b}, SCHÖNING, Alexander\textsuperscript{c}, TRUX, Anneke\textsuperscript{d}, VAN DEN AKKER, Elisabeth\textsuperscript{e}, WEGNER, Martina\textsuperscript{f}, and GERHARTSREITER, Tobias\textsuperscript{g}

\textsuperscript{a} GIZ\textsuperscript{2}, Bonn, Germany. e-mail: klaus.ackermann@giz.de
\textsuperscript{b} GIZ, Eschborn, Germany. e-mail: dieter.nill@giz.de
\textsuperscript{c} GIZ, Bonn, Germany. e-mail: alexander.schoening@giz.de
\textsuperscript{d} GIZ, Bonn, Germany. e-mail: anneke.trux@giz.d
\textsuperscript{e} GIZ, Eschborn, Germany. e-mail: elisabeth.akker-van@giz.de
\textsuperscript{f} GIZ, Eschborn, Germany. e-mail: martina.wegner@giz.de
\textsuperscript{g} GIZ, Bonn, Germany. e-mail: ccd-projekt@giz.de

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\textbf{Abstract} – In the Sahel, people have always faced extreme climate conditions with high rainfall variability. Rising population density, unsustainable cultivation practices and depletion of natural resources, particularly of soils, continue to accelerate desertification. This situation is further exacerbated by the effects of climate change, resulting in increased stress on the eco-systems and higher vulnerability of the rural population. Since the 1980s, German development cooperation (GDC) has been providing support to people in the Sahel region through development and implementation of improved natural resource management strategies and approaches. A special emphasis was put on soil and water conservation (SWC), and soil protection and restoration (SPR). In this paper several techniques and approaches of SWC / SPR are presented. Their contribution to improving the resilience of prevailing agro-sylvo-pastoral systems and to reducing the vulnerability of rural populations is also examined. A special focus is on water spreading weirs, a relatively new technology introduced in the Sahel by the Swiss and German development cooperation for the rehabilitation of degraded dryland valleys. This technique is part of a spatial approach that combines several land management techniques that reduce soil erosion and improve soil fertility and food security. Finally, the paper gives policy and technical recommendations for up-scaling the techniques presented in order to contribute to sustainable land management and resilience building on the ground.

\textbf{Keywords} – soil and water conservation, resilience, climate change adaptation, food security

1. Introduction

More than 10 million people in the Sahel suffered from food crises in 2010 (Gubbels, 2011). Also in 2012, a significant percentage of the population in the region was affected by food insecurity. This situation was exacerbated by the conflict in northern Mali that forced many people to leave their home regions. Globally, about 18 million people are at risk of hunger within the West African Sahel (European Commission, 2012). Food security crises in the Sahel have a cyclic character and are caused by complex factors, the most determinant of which are natural phenomena such as droughts and locust outbreaks (Sendzimir et al., 2011). The periods of 1942-49, 1968-73 and 1982-84 comprise the most illustrative drought-related famine events in the region (Reij et al., 2009).

Inter-annual climate variability is a typical characteristic of dry regions like the Sahel. People have learnt over time to cope with and to adapt to permanent water scarcity, erratic rainfall and risks of climate related...
shocks. But due to different factors, such as high poverty rates, changing socio-economic and political conditions, population growth and degrading natural resources of these traditional adaptive strategies have become insufficient, while others prove to be unsustainable (UNCCD et al., 2009). Meanwhile, due to new political and economic conditions other traditional practices and approaches such as the farmer managed natural regeneration (FMNR) in Niger which had been abandoned in favour of rather unsustainable practices, are now being reconsidered and promoted (Sendzimir et al., 2011; Reij et al., 2009).

In general, drylands are more vulnerable to the effects of climate change because the populations have low adaptive capacity. Therefore in the Sahel in particular, climate change must be seen as an additional pressure to the already unstable livelihoods. Increased dependence on natural resources adds to ecosystem fragility, increased poverty and unfavourable political conditions to complicate vulnerability in dry areas (Sörensen et al., 2009).

Therefore, strengthening the adaptive capacity of vulnerable households should be the lead action when seeking to enhance resilience of rural livelihoods in the Sahel. As explained by Frankenberger et al. (2012: 3), this commends that the nature and extent of access to and use of resources be the focal points in order to succeed durably. Resilience and vulnerability being oppositely related, reducing vulnerability means increasing resilience. Frankenberger (2012) proposed descriptive pathways specific to either concept, stating that households that are able to adapt to shocks and stresses (adaptive capacity) and to incrementally reduce their vulnerability are on a resilience pathway. The holistic framework of resilience is appropriate to guide long term and multisectoral interventions, integrating emergency operations, reduction of risks as well as climate change adaptation and development (Gubbels, 2011). An important resilience factor in rural Sahelian areas is agro-ecological agriculture which encompasses such conservative practices as agro-forestry, integrated livestock/agriculture, soil and water conservation, crop management and integrated pest management, etc. These approaches contribute to secure and/or increase agricultural yields, to regenerate natural resources, and to improve income, resulting in improved food security and resilience (Gubbels, 2011).

This paper is to present some of the key factors determining vulnerability and resilience of rural livelihoods in the Sahel region. It also discusses the potential of sustainable land management practices such as soil and water conservation (SWC) and soil protection and restoration (SPR) as based on GDC practical experiences.

2. Main factors determining resilience in the rural Sahelian region

The causes of instability in the Sahel region are complex and cut across several sectors. They include low productivity, inadequate access to food and health care, malnutrition, missing social safety nets, and poor infrastructure (Mertz et al., 2009; European Commission, 2012). Underlying causes include the degradation of ecosystems and the effects of climate change that destabilize agricultural production systems. Economic disparities and weak public institutions further contribute to lessen resilience in the region. In the following sections, selected resilience factors with special effects of the natural resource base will be presented in more detail.

2.1. Population growth

The population of the African continent has grown at 2.5 per cent annually for the past 60 years from 186 million in 1950 to 856 million in 2010 (UNDP, 2012). In most of the Sahelian countries the population grew even more than 3 per cent per year. In 2050 the African population will probably reach 2 billion, whereas faster growth is projected for East and West Africa. This rapid growth combines with shifting diets towards processed food, meat and dairy products to increase the pressure on food systems and natural resources. It is expected that food supplies will double in the next few decades (UNDP, 2012; Foley et al., 2011). However, the expansion of agricultural areas in the tropics must not be considered as a solution, as experience shows the increase in acreage has more effect on reducing biodiversity than on increasing food supply. In effect, across the tropics, between 1980 and 2000 83 per cent of new agricultural land came at the expense of forests, while 55 per cent came from intact forests and another 28 per cent from disturbed forests (Gibbs et al. 2010; Foley et al., 2011). Consequently ecosystem services are being depleted while greenhouse gas emission increases. Therefore, more effort in technical improvement is needed on existing agricultural lands, fuel crop production needs to be reduced for international demands and awareness about birth control promoted.

Indisputably, all of these factors make soil fertility management an essential key to agriculture sustainability (Kandji et al., 2006).

2.2. Land degradation

Measuring the extent of desertification on a bigger scale always relies on qualitative assumptions and scientific models. According to Zika and Erb (2009), globally about 23 per cent (12 Mio. km²) of drylands are affected by desertification. Some authors suggest even higher numbers, reaching up to 71 per cent (36 Mio. km²) (Dregne u. Chou 1992). According to the GLASOD study, desertification in Africa is particularly alarming as about 10 per cent of the continent’s land area is affected (Oldeman et al 1991). Estimates by Reich et al., (2001) attained 46 per cent of the African land mass, with over 485 Mio. people concerned. The situation is compounded by climate change and increasing population pressure. In effect, between 1990 and 2025 the average agricultural area per capita in Sub-Saharan Africa will decrease by 61 per cent to 0.63 ha (Norse et al 1992). In some areas of Niger in particular, up to 50 per cent of the landmass have already become totally unproductive due to land degradation (Gubbels, 2011). Soils in the Sahel are very fragile, poor in plant nutrients and prone to erosion. Torrential summer rains...
and limited soil water absorption capacity cause high water runoff (40 per cent of annual precipitation are common) making soils highly sensitive to erosion and crusting. About 100 tonnes of soil per hectare per year are common rates of rain erosion. Additionally in some areas, wind erosion can amount to 150 tonnes per hectare. Wind and water erosion are considered the main constraints to agricultural sustainability in the Sahel, contributing to a large extent to desertification (Kandji et al., 2006). Land degradation is caused by different other factors, including the following:

- Insufficient or non-existent spatial planning; land use plan for sustainable land management is often missing or not implemented
- Traditional strategies of natural resource management have become unsustainable under continued population growth, mostly because they tend to encourage abusive exploitation (overgrazing, bushfires, deforestation and abusive wood cutting and pruning, etc.)
- Insufficient / lack of land tenure security that favours unsustainable land use practices
- Increasing climate risks such as droughts and onset of desertification process
- Salinisation as a result of improper irrigation

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2.3. Climate change

The Sahel is characterised by wide climate variations with succession of dry and wet years and irregular rainfall between (200-600 mm). Temperatures in West Africa increased by an average of 0.5-0.7°C between 1951 and 2001, with an increase of around 0.7°C in the minimum temperature and 0.35°C in the maximum temperature (Sarr and N’Djafa Ouaga, 2009). This climate variability stands as the major constraint to assuring food security in the region (Kandji et al., 2006).

As shown in figure 1, analysis of the rainfall pattern in the Sahel reveals three important climate periods:

1. 1950-1968: a period of high rainfall with year-to-year variability and an overall downward trend;
2. 1968-1993: a dry period with high year-to-year variability;
3. 1993-2006: a period of very high year to year variability with humid years alternating with dry years.

Climate projections predict a warming of 0.2°C to 0.5°C per decade across the African region, with higher temperatures within the Sahel and in central southern Africa (Kandji, 2006). As a result, local conditions will exacerbate because of higher evapotranspiration. While predictions are unclear about future trends of rainfall, the following may still be expected:

- Higher temperatures and more frequent heat waves
- Decline of annual precipitation in North and South Africa; increase in East Africa
- Longer drought periods in North and South Africa, and shorter droughts in East Africa
- Increase in rainfall intensity over the whole continent
- Decreasing trend in the duration of the wet season in parts of West Africa

Even under unchanged annual precipitation, higher rain intensity will combine with frequent droughts and floods to increase risks of soil erosion and vegetation de-
struction (Mertz et al., 2009; Kandji et al., 2006; Sörensen et al., 2009).

3. German development cooperation in the Sahel

Since the eighties of the 20th century, German Development Cooperation has developed and implemented soil and water conservation approaches in the Sahelian countries. Big rural development projects in Niger, Burkina Faso, Chad and Mauritania supported rural populations by providing knowledge about soil and water conservation technologies.

Communities and user groups have been trained in land use planning and implementation of measures that reduce water run-off and improve soil fertility. These efforts were accompanied with management instruments such as "local conventions" signed between user groups to prevent conflicts, and helped to protect vast landscapes against desertification. Similar approaches were used by other international partners and donors like FAO and the Swiss Cooperation (SWC). Because of increased poverty and vulnerability in the region, the SWC approach included social measures, such as Food-for-Work or Cash-for-Work in order to encourage participation, with expectations that in the long-term people will understand the positive impact on the environment and on their livelihoods and will therefore become sensitive to land degradation. Reclaimed lands are used for agriculture, grazing and forestry. Livelihood systems become more diversified and resilient against droughts and other adversities. Soil and water conservation/soil protection and restoration (SWC/SPR) measures were one of the priorities of the German cooperation in the Sahel region. The following sections will discuss these measures in detail.

4. Soil and water conservation/soil protection and restoration (SWC/SPR)

SWC/SPR measures aim to achieve various goals:

1. to improve water management,
2. to increase the productivity of croplands, forestlands and rangelands and
3. to ensure sustainable management at the environmental, social and economic levels.

With regard to beneficiary groups in particular, the goal is to improve income, food and nutrition security by guaranteeing, increasing and diversifying production in order to enable them to cope better with lean seasons. In social terms, the goal is to improve the organisational capacities of rural communities, to promote rational use of natural resources and to prevent conflicts. Overall, SWC/SPR measures contribute to raise the water table, improving water availability for humans and animals. In environmental terms, they improve local ecology through soil erosion control, and improved soil fertility. SWC/SPR measures therefore improve and stabilize the livelihoods of local populations, and increase their resilience against external factors.

SWC/SPR measures are implemented taking into account the topographical units of the entire watershed, including plateaus, slopes, pediments and valley bottoms. These topographical units have different types of soil, vegetation and capabilities and are often exploited by different user groups under different forms of land tenure (figure 2).

The plateau areas are usually communal lands with shallow, infertile, stony soils. As such, they are generally over exploited as grazing lands and for various forest products, including wood, straw, fruits, bark and other non-ligneous products.

Slopes also have shallow, stony soils with grass and bush cover. Under the effect of highly erosive rains that characterise the region, small ditches and gullies impart the landscape of the plateaus and hillsides, and contribute to limit their use for grazing areas.

Pediments are located in the piedmont areas of the plateaus. They have gentle slopes and are prone to sheet and gully erosion. Because of their deeper and more fertile soils, pediments are predominantly used for rain-fed agriculture.

The valley bottoms have deep, more fertile soils enriched with fertilising elements transported from upstream. Because of their moisture advantage, valley lands are used to grow high moisture demanding crops such as rice and maize during the rainy season; but they are also used as grazing lands. During the dry season, the shallow water table enables irrigation agriculture for subsistence and cash crop production. In general, the water streams that converge to the valley are strong and loaded with alluviums, and therefore, often cause severe erosion, clog the water beds and damage the hydro-agricultural infrastructures.

There is no one-size-fits-all technical solution in land management: Each situation needs specific measures that must take into account the land use objectives, the specificities of the land to be improved (topography, soil properties and structure, type of degradation, vegetation cover, watershed influence, etc.), as well as the local climate factors (rainfall characteristics, temperatures, evapotranspiration rates, wind characteristics). Therefore, the assessment of whole watershed becomes essential for success as this permits to select the most appropriate techniques and approaches to combine, not to propose strategies that would be technically and economically inaccessible to the farmers and which would not have plausible direct effects. This assessment must be conducted using participatory methodologies, involving the local populations and even people from neighbouring areas. Such participatory assessments enable to bring to light potential conflicts over lands, to raise the populations’ awareness about the stakes of land degradation, and to facilitate their adhesion to project activities. Effective participation of the population strengthens their expertise in SWC/SPR techniques along with their organizational and management capacities, and cuts down project costs.

The roles of SWC/SPR measures are rather simple: They break the speed, and therefore the strength of the water flow, stopping or slowing it down, in order to give
time to the water to infiltrate the soil. This way, the water table is recharged to better feed the plants. In so acting, SWC/SPR measures reduce, not only rainwater loss, but also fertilisers (manure and chemical fertilisers) losses.

5. Water spreading weirs

Water spreading weirs are a relatively new technology aimed at rehabilitating degraded inland valleys. Introduced in the Sahel in the late nineties by Swiss and German development cooperation, this technology has been refined during the last 10 years and is now widely implemented in Burkina Faso, Niger and Chad with potential for further up-scaling.

Water spreading weirs are stone and cement constructions that extend from one side of the valley to the other. Usually built in a series to stabilise the entire valley, the weirs allow spates to flow over and flood the land below, thereby increasing the area that is usually flooded. Because speed of the water flow is reduced, fertile soil is deposited, and water infiltrates into the ground, lifting the water table. This allows farmers to grow crops all year round (rain-fed and irrigated), even on formerly degraded lands, thereby contributing to food security and resilience. In most cases rehabilitated lands are used for production of high value crops like vegetables. Although cost-benefit studies are still underway, there are indications that the cost of rehabilitation ranges between € 400 – 2000 per hectare and can be recovered with the additional harvest of one year, depending on the type of crop, state of degradation, the type of valley and the region. In any case, the cost of a water spreading weir is much lower than that of a dam.

Both the effectiveness and sustainability of water spreading weirs require:

1. participatory planning with the local population,
2. that they be considered as a land use planning instrument;
3. clear land rights, and
4. the creation and training of local maintenance structures.
Although the maintenance of the weirs are little demanding, it is advised to develop the technical capacity of local contractors and government officers, mostly to cope with important damages that may happen. These technical capacities must be passed-on to subsequent groups and generations in order to ensure long term sustainability.

In conclusion, water-spreading weirs permit the rehabilitation of degraded inland valleys and constitute an effective means for erosion control and agricultural soils rehabilitation. They contribute to optimise water and soil management, thereby increasing agricultural production, sustainably. Water spreading weirs are not a stand-alone technology, but they complement other anti-erosion measures, e.g. on hillsides and on plateau areas. They form an integral part of watershed management and can be implemented in a wide range of environmental conditions. Therefore, they are suitable for up-scaling to other semi-arid regions within and beyond the Sahel.

6. Conclusions and recommendations

SWC/SPR measures are effective ways of improving water resources management and of reducing the degradation of soil, vegetation and biodiversity. As such, they contribute to mitigate the effects of climate change, improving soil fertility, plant cover and biodiversity toward more secure livelihood and higher standard of living for rural communities. Training in SWC/SPR techniques also result in more appropriate land use planning at the local and communal levels, more rational use of natural resources, more secure land tenure and less risks of conflicts.

The adoption of SWC/SPR measures is a promising solution for countries in the Sahel, but it requires a long-term commitment. To implement these measures over a geographic area wide enough to achieve significant impacts would necessitate sustained state-wide commitment over several generations. More specifically, governments must ensure that communities are well organized and effectively adopt SWC/SPR measures. Without close monitoring, SWC/SPR programs will lose momentum. While international support is necessary to finance investments, experience has shown that only this kind of long-term commitment leads to success. Traditional short-term projects can only contribute specific investments in the broader land improvement framework.

6.1. Recommendation for the promotion and implementation of agro-ecological practices

In order to ensure that the most vulnerable groups are reached the impact of agro-ecological systems must be monitored across farmers of all economic classes (see also Gubbels, 2011).

Rather than promoting isolated SWC/SPR techniques, synergetic approaches should be advocated, combining several techniques and methods in flexible ways in order to ensure that the social, economic and environmental specificities of the area are taken into account (see also Reij et al., 2009). To design a coherent package of appropriate technical measures for addressing ecologic and social priority vulnerabilities, a landscape approach based on spatial analyses and planning would be advisable.

By combining and inter-linking techniques and approaches that address individual household interests with those that address communitywide interests, local ownership and thus sustainability will be fostered. As local ownership is strengthened, farmer-to-farmer based experience exchange and trainings must be promoted.

6.2. General recommendations

Long-term measures including rehabilitation and sustainable management of fragile ecosystems are necessary to address root causes of vulnerability. Development pro-
grammes must therefore foresee long-term engagement.
One priority in order to ensure the feasibility of long-term measures must be the promotion of stable and secure land tenure which includes traditional land use and resource management regimes as well as modern property regimes.

References


Citation