SLM practices for dryland restoration: an overview with a special focus on arable land

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Sustainable Land Management Practices for Dryland Restoration. A Review

Journal of Environmental Planning and Management
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17 co-authors, mainly from WG4

Chapters: (-> presentations in this conference)
> Water management (-> Mehreteab Tesfai)
> Arable lands (-> Gudrun Schwilch)
> Rangelands (-> Thorunn Petursdottir)
> Forests:
   — Post-fire restoration in Mediterranean forest (-> Thomas Panagopoulos)
   — Dry forest ecosystem restoration (-> Eshetu Yirdaw)
> Coastlands
Apparently we are not doing enough to protect our land
SLM is defined as the use of land and water resources, including *soils, water, animals and plants*, for the production of goods to meet *changing human needs*, while simultaneously ensuring the *long-term* productive potential of these resources and the maintenance of their *environmental functions*.

(www.wocat.net)

Trade-off:

**Immediate human/economic needs** versus

**Long-term ecosystem services**
Arable land – some global figures

In the last 50 years

> agricultural production 2 - 4 % increase / year
> cultivated area has grown by only 1 % / year
> > 40 % of the increase in food production has come from irrigated areas, which have doubled in size
> global cultivated land per person: declined from 0.44 ha to less than 0.25 ha -> = successful agricultural intensification
> Potential productive land is
  — unevenly distributed over a few countries
  — much of it is characterized by significant agronomic and suitability constraints
> Drylands: increasing water scarcity, vulnerable soils

Increase agricultural production through

- Increase land productivity
  - New machinery
  - Fertilizers
  - Genetically modified crop varieties
  - Crop diversification
- Expand arable land area
  - Mainly possible in Africa
  - Mainly affects semi-arid savannahs and grasslands, tropical rainforests, and peat lands
    -> at risk of degradation!
- Rehabilitate degraded lands to productivity

Key to improved land productivity and food security
Source: Liniger et al. 2011.
Sustainable Land Management SLM:
Prevention, mitigation, restoration interventions.

- Rehabilitation: 24% (n=73)
- Prevention: 24% (n=73)
- Mitigation: 37% (n=110)
- Prevention and Rehabilitation: 4% (n=11)
- Prevention only: 2% (n=6)
- Prevention and Mitigation: 2% (n=6)
- Mitigation only: 7% (n=21)
- Mitigation and Rehabilitation: 2% (n=6)
- Rehabilitation only: 4% (n=11)
- Prevention/rehabilitation/mitigation: 4% (n=11)

n=300, 63 blanks, Only first ranks were considered.
SLM practices: some key principles

Support the water, nutrient and biomass cycles through:
> maintaining and enhancing soil cover,
> reducing top soil disturbance and compaction,
> rotating and interplanting crops/plants,
> integrating crop and livestock systems,
> enhancing plant and animal species diversity, and
> balancing nutrient withdrawal and replenishment

Divert / drain runoff & runon
Where there is excess water in humid environments, or at the height of the wet seasons in subhumid conditions, the soil and ground water can become saturated, or the soil’s infiltration capacity can be exceeded. Thus safe discharge of surplus water is necessary. This helps avoid leaching of nutrients, soil erosion, or landslides. It can be achieved through the use of graded terraces, cut-off drains and diversion ditches etc.

Impede runoff (slow down runoff)
Uncontrolled runoff causes erosion - and represents a net loss of moisture to plants where rainfall limits. The strategy here is to slow runoff, allowing more time for the water to infiltrate into the soil and reducing the damaging impact of runoff through soil erosion. It is applicable to all climates. This can be accomplished through the use of vegetative strips, earth and stone bunds, terraces etc.

Retain runoff (avoid runoff)
In situations where rainfall limits plant growth, the strategy is to avoid any movement of water on the land in order to encourage rainfall infiltration. Thus water storage is improved within the rooting depth of plants, and groundwater tables are recharged. This is crucial in subhumid to semi-arid areas. The technologies involved are cross-slope barriers, mulching, vegetative cover, minimum / no tillage etc.

Trap runoff (harvest runoff)
Harvesting runoff water is appropriate where rainfall is insufficient and runoff needs to be concentrated to improve plant performance. Planting pits, half moons etc. can be used. This can also be applied in environments with excess water during wet seasons, followed by water shortage: dams and ponds can further be used for irrigation, flood control or even hydropower generation.

Reduce soil evaporation loss
Water loss from the soil surface can be reduced through soil cover by mulch and vegetation, windbreaks, shade etc. This is mainly appropriate in drier conditions where evaporation losses can be more than half of the rainfall.

Source: Liniger et al. 2011.
Overviews and assessments of SLM

Many overviews and assessments of SLM successes, but many have focused on

— a specific technology group

— a specific biophysical aspect
  (Sahrawat et al. 2010, Crittenden et al. 2014, 2015)

— mainly evaluate economic productivity
  (Farooq et al. 2011, Bayala et al. 2012)

Some arable land SLM groups

— Integrated soil fertility management
— Conservation agriculture
— Cross-slope barriers
— Agroforestry
— Integrated crop-livestock management
— (Water harvesting)
Integrated soil fertility management

Practices that aim to improve soil fertility and simultaneously enhance soil structure and water infiltration through organic manures, compost, green manure (nitrogen fixing crops) or mineral fertilizers.

1. maximising the use of organic sources of fertilizer;
2. minimising the loss of nutrients;
3. judiciously using inorganic fertilizer according to needs and economic availability

T_SPA005en, J.de Vente; in Schwilch et al. (2012)
Conservation Agriculture

A system characterized by three basic principles:
1. minimum soil disturbance,
2. a degree of permanent soil cover,
3. crop rotation

Reduced- or no-tillage

No-tillage agriculture in the Cauquenes Region, Chile

Crop rotation

Lupins forming part of the crop sequence in Mediterranean Chile
Cross-slope barriers

Structures or permanent vegetative strips that reduce slope steepness and/or length. Permanent vegetative strips can develop into terraces over time.

Aloe Vera living barriers
Cape Verde - Barreiras Vivas de Aloe vera (Portuguese)

It is a technique which uses the structure of a cross-slope barrier of Aloe vera to combat soil erosion by decreasing surface wash and increasing infiltration.

Aloe vera is a durable herbaceous plant which is planted in the form of living barriers to recover degraded slopes on the Cape Verde Islands.

The plants are closely planted along the contour to build an efficient barrier for retention of eroded sediments and superficial runoff. The living hedges of Aloe vera stabilize the soil, increase soil humidity by improving infiltration and soil structure. Groundwater is recharged indirectly. Soil cover is improved, and thus evaporation and erosion reduced.

Implementation is relatively simple. The contour lines are demarcated using a water level. Seedlings are planted along one line at a distance of 30-50 cm between plants, spacing between the rows varies between 3-5 m according to the slope. The technology is applied in subhumid and semi-arid areas, on steep slopes with shallow soils, a poor vegetation cover and high soil erosion rates. These areas are generally used by poor subsistence farmers for rainfed agriculture with crops such as maize and beans, which are considered inappropriate for such slope angles. On slopes steeper
Agroforestry

Woody perennials are deliberately integrated with agricultural crops and / or livestock

- spatial mixture (e.g. crops with trees) or in a
- temporal sequence (e.g. improved fallows, rotation)

Examples:

- alley cropping
- farming with trees on contours
- perimeter fencing with trees
- multi-storey cropping
- relay cropping
- intercropping
- bush and tree fallows

T_KEN16en, J.M. Mwaniki; in Liniger & Critchley (2007)
Integrated Crop-Livestock Management

- Crops and livestock interact to create synergies, making optimal use of resources.

- The waste products of one component serve as a resource for the other:
  - manure from livestock is used to enhance crop production (improve soil fertility),
  - crop residues and by-products (grass weeds and processing waste) are supplementary feed for the animals

G. Schwilch
Up-scaling SLM

- The established scientific evidence is rarely driving adoption of SLMs
- Up-scaling SLMs has thus to recognize and build on
  - local traditional practices and experimentation
    (Stringer et al 2014),
  - favorable cost-benefit ratio
  - local policy and tenure arrangements
    (Teshome et al., 2015),
  - a participative approach
- The decision to adopt SLM practices depends on physical and agro-climatic farm conditions, socioeconomic circumstances, and governance factors
  (Knowler and Bradshaw, 2007)
Benefits of SLM regarding dryland threats

<table>
<thead>
<tr>
<th>Desertification threat</th>
<th>Related SLM benefits</th>
<th>Impact achieved by DESIRE SLM technologies</th>
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<tbody>
<tr>
<td>Water scarcity</td>
<td>Improved water management through increased water quantity, reduced water loss through runoff and evaporation, improved soil moisture, improved water harvesting, recharge of groundwater</td>
<td>High impact, mainly through water management, cropping management, and cross-slope barriers</td>
</tr>
<tr>
<td>Soil degradation</td>
<td>Reduced soil loss, reduced crusting and sealing, reduced damage on neighbors’ fields and public/private infrastructure</td>
<td>Very high impact, mainly through cropping management and cross-slope barriers, but also through forest and grazing management</td>
</tr>
<tr>
<td>Vegetation degradation and low production</td>
<td>Improved soil cover, improved biomass, diversified and enhanced production, improved water use efficiency, improved soil organic matter, improved pest and disease control, reduced risk of production failure, increased farm income</td>
<td>Medium to high impact by all technology groups; water management shows smallest impact</td>
</tr>
<tr>
<td>Climate change</td>
<td>Resilience towards climate change and variability through reduced vulnerability towards adverse events, reduced risk of production failure, reduced downstream flooding, diversification of income sources</td>
<td>Medium impact, mainly through water management and cross-slope barriers. Sensitivity of cropping management to droughts and water management to floods.</td>
</tr>
<tr>
<td>Resource use conflicts, migration</td>
<td>Socio-cultural benefits including conflict mitigation, prevention of outmigration, institution strengthening, improved knowledge of conservation/erosion</td>
<td>Medium to high Impact on improved livelihoods and knowledge through all technology groups; some impact on conflicts and migration by most technology groups</td>
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Identify, evaluate and select SLM options

- **Part I – Identification:**
  Identify existing and potential strategies with a *participatory learning approach* (stakeholder workshop 1)

- **Part II – Assessment:**
  Evaluate, document and share strategies with *standardised questionnaires*

- **Part III – Selection:**
  Select the most promising strategies with a *decision support tool* (stakeholder workshop 2)
SLM field testing in Sehoul, Morocco

Cropping season: No tillage (direct seeding) versus conventional ploughing

Dry season: Grazing versus enclosure

Daily averages of soil moisture content at 5 cm depth, Oct–Dec 2009, Jyahna

Soil moisture measuring
Ecological impacts

Increased soil moisture

Improved harvesting/collection of water
Socio-economic impacts

Increased production (crop yield, fodder, animal and wood)

Short-term benefits in relation to establishment costs

Long-term benefits in relation to establishment costs
Standardized tools & harmonized products

A common global platform for SLM

WOCAT is the primary recommended database for reporting on SLM Best Practices of UNCCD

> 500 SLM practices
New policy-relevant scientific advisory mechanisms

New network of scientists to provide independent science and knowledge on land degradation and SLM:

- DesertNet International
- WOCAT
- Global Network of Dryland Research Institutes (GNDRI)

- Intergovernmental Science-Policy Platform on Biodiversity Ecosystem Services (IPBES, established in 2012)
- Intergovernmental Technical Panel on Soils (ITPS, established in 2014).
Conclusions

Essential pillars to better understand, prevent, and restore land degradation:

- **Transfer of scientific knowledge**
  Scientists should make an effort to improve the knowledge exchange with all potential stakeholders.

- **Good governance**
  Policy makers must consider the combined social-cultural, and ecological benefits, accounting for trade-offs as well as off-site effects of SLM projects.

- **Public participation**
  Developed countries should learn from developing regions where effective long-term restoration programmes have been carried out with the participation of stakeholders.
Thank you!

COST Action ES1104 Working Group 4 in Timisoara, Sep 2014