INTEGRATED CROP-LIVESTOCK MANAGEMENT

Pegged small-stock on harvested cropland, Cape Verde. (Hanspeter Liniger)

In a nutshell

Definition: In Integrated Crop - Livestock Management (ICLM) 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), whilst crop residues and by-products (grass weeds and processing waste) are supplementary feed for the animals. Grass – and prunings from agroforestry trees - grown on contour conservation barriers, as well as nitrogen-fixing legumes grown under conservation agriculture systems, are further potential sources of fodder. Livestock are integral to most African cropping systems: they provide traction and transport, as well as meat, milk and hides. Improvements to the livestock component of integrated systems include upgraded intensive pastures through shifting night enclosures (kraals / bomas), fodder planting / hay making, and stall feeding ('cut-and-carry'; 'zero grazing') in the more humid areas. Various factors influence the type and effectiveness of crop - livestock interactions, including socio-economic parametres (access to land, labour and capital) and ecological conditions (temperature and rainfall).
Applicability: Integrated crop - livestock systems are common in semi-arid and subhumid (and humid) areas as well as in tropical / temperate highlands. Given the growing demand for livestock products, the subhumid areas are predicted to the best potential to provide most of this increase. ICLM can be applied in many areas, but needs to be adapted and modified to prevailing conditions.
Resilience to climate variability: ICLM systems tend to be relatively well adapted to climatic variability because of their diversity and flexibility – especially when soil and water conservation / water harvesting and agroforestry are integrated into the overall system.
Main benefits: Well managed ICLM (a) increases crop yields; (b) improves soil biological activity and health; (c) builds up fertility through nutrient recycling, the planting of leguminous crops and trees; (d) reduces erosion; (e) intensifies land use, improving profits; and (f) improves livestock productivity and health. Including animals in farm systems increases sustainability and reduces reliance on external inputs. Carbon storage can be high: in one case from West Africa, soil receiving manure for five years had 1.18 t/ha more carbon present than soil treated with plant residues alone (Woodfine, 2009 and FAO, 2007). Nevertheless, the carbon budget of such systems is affected negatively by methane emitted by livestock. ICLM thus reduces poverty and malnutrition, and strengthens environmental sustainability.
Adoption and upscaling: Skillful organisation and management of animals and the land is needed. Rules and regulations have to be followed by all concerned, particularly with regard to exclusion of areas from grazing and in terms of animal health and nutrition. Specific skills can be taught, but much must be learnt through experience.

Development issues addressed	
Preventing / reversing land degradation	++
Maintaining and improving food security	++
Reducing rural poverty	++
Creating rural employment	+
Supporting gender equity / marginalised groups	++
Improving crop production	++
Improving fodder production	++
Improving wood / fibre production	+
Improving non wood forest production	+
Preserving biodiversity	++
Improving soil resources (OM, nutrients)	++
Improving of water resources	+
Improving water productivity	++
Natural disaster prevention / mitigation	+
Climate change mitigation / adaptation	++

Climate change mitigation	
Potential for C Sequestration (tonnes/ha/year)	0.1- 0.8*
in silvo / agro-forestry systems	up to 3*
C Sequestration: above ground	++
C Sequestration: below ground	++

Climate change adaptation	
Resilience to extreme dry conditions	++
Resilience to variable rainfall	++
Resilience to extreme rain and wind storms	+
Resilience to rising temperatures and evaporation rates	+
Reducing risk of production failure	++

** for a duration of the first 10-20 years of changed land use management (Source: Woodfine, 2009)*

Origin and spread

Origin: Traditional agriculture in Africa was generally based on mixed crop-livestock systems, with pure livestock production predominating only when rainfall was too low and uncertain to support some form of crop production. Pure arable systems only developed when large-scale mechanised cereal farming was introduced, or where cash crops such as coffee, tea or sugar cane expanded. Animal disease may also have played a role in some areas. Today the re-discovery and modification of traditional techniques, including rotational land use / fallows, mixed cropping, grazing rules and regulations, in combination with agroforestry, improved fodder species, specific soil and water conservation measures (SWC) and more productive livestock breeds, make these systems stronger and more versatile.
Mainly applied in: Ethiopia, Kenya, South Africa, Tanzania, Zambia, Zimbabwe
Also applied in: Burkina Faso, Mali, Senegal

Integrated Crop-Livestock Management in SSA.

Principles and types

ICLM is evolving as a very viable and common farming system, allowing smallholder farmers to capitalise on the complementarity and synergies between crops and livestock for improved cycling of nutrients, efficient resource use, and safeguarding the environment. Some activities / measures in an integrated crop livestock system are:
Animals stall-fed (zero-grazing) has expanded significantly through the introduction in the more humid areas of (particularly) dairy cows. This has led to an all-round intensification of crop – livestock systems. Combined with vegetative SWC measures, based often on napier grass which is an excellent fodder, as well as agroforestry, and sometimes biogas plants, whole farming systems have been upgraded.
Harvesting and relocating nutrients: Crop residues are sometimes stored but most are left in the field after harvest, opportunistically grazed and often underutilised (and spoiled). Land users can paddock animals on cropland or otherwise collect (sometimes store and process) and spread manure on cropland to improve fertility and hence production. In agropastoral systems animals graze freely during the day and are in *kraals* / *bomas* (enclosures for cattle, goats and sheep) or on cropland during the night. The balance of feed that an animal consumes influences the properties of its gaseous emissions (especially methane, CH_4), and manure management is important in this context.
Dual-purpose crops (food-feed) enable farmers to increase unit area productivity with the same resources. Significant advances have already been made in the development and promotion of dual-purpose cowpeas in West Africa and maize in Kenya.
Addition or control of species involves improving grazing land through planting high-value species (e.g. grasses, multi-purpose shrubs / trees) for increased biomass production ('enrichment planting'), eradicating invasive species by selective cutting, while simultaneously encouraging natural regeneration of desirable local species. Under dry conditions, water harvesting techniques can be useful.
Haymaking allows the building up of reserves for the dry season from surplus in the wet. Storing fodder helps animals to survive during dry periods without having to overgraze the land. It is also a buffer in extreme drought when market prices for animals are very low. The conservation of fodder as hay or silage, however, has not been a common practice in small-scale farming systems in SSA due to lack of information on conserving fodder under tropical conditions, and the resilience of local breeds to harsh conditions and poor diets.
Production of forages, grasses and leguminous trees is often through being grown on bunds and intercropped with food or cash crops. Live fences can also serve the same purpose.
Enclosures: If pasture is severely degraded due to overgrazing then fencing (social as well as physical) is often the first step, followed by a period of several years of rest. After good regeneration and regrowth, cut-and-carry or controlled grazing (e.g. rotational grazing) leaving periods of recovery of the vegetation are the management systems that maintain the land's condition.
Animals for field work and transportation constitute an appropriate, affordable and sustainable technology that is used in most countries in SSA. Draft animals, notably cattle and donkeys, provide smallholder farmers with vital power for cultivation and transport. Animal traction can also be used for water-raising, milling, logging, land-leveling and road construction.




Top: Cow stall fed with crop residues, Kenya. (Hanspeter Liniger)
Middle: Transportation of grass for stall feeding, Ethiopia. (Hanspeter Liniger)
Bottom: Stall feeding of dairy cows, Uganda. (William Critchley)

Applicability

Land degradation addressed

Chemical soil deterioration: fertility decline and reduced organic matter content
Biological degradation: reduction of vegetation cover and species composition / diversity decline, loss of fodder value
Poor animal health due to limited availability and quality of feed
Fire is a widely used management practice for vegetation clearance, growth stimulation and pest control. Rangeland and crop residue burning, besides emitting CO_2, reduces soil organic matter and nutrient levels.

Land use

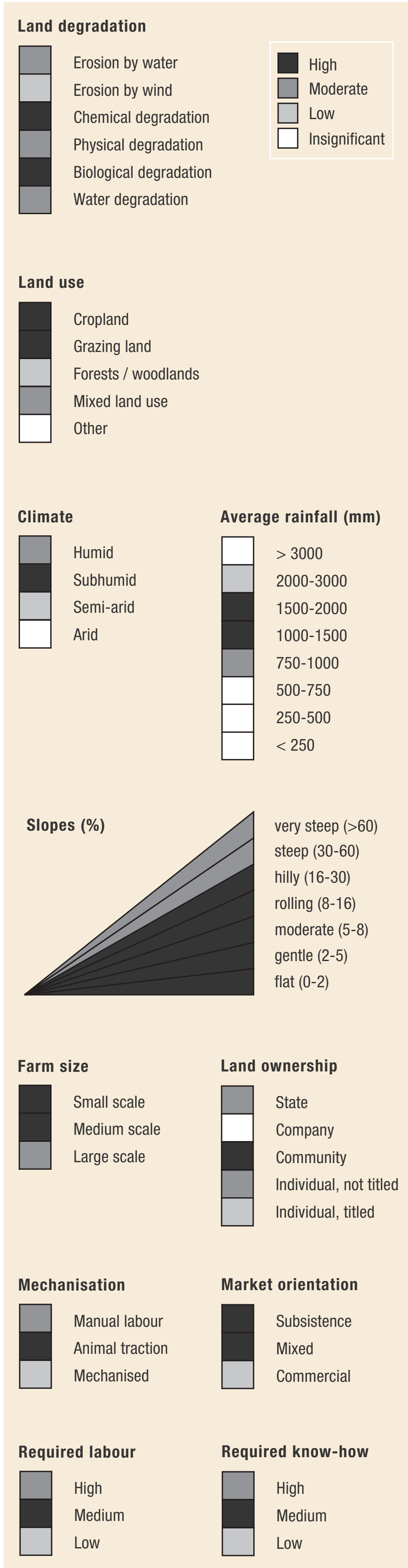
Mainly cropland and mixed land use
Also intensive grazing / fodder production (improved or planted pastures, etc.)

Ecological conditions

Climate: mainly subhumid to humid areas, partly in semi-arid, with rainfall mainly between 750-1,500 mm (though even higher also)
Terrain and landscape: no restrictions whole range from flat to hilly
Soils: no restriction

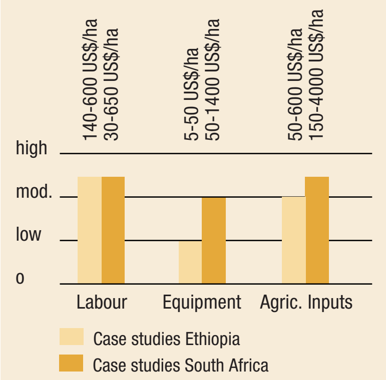
Socio-economic conditions

Farming system and level of mechanisation: Mainly on small-scale to medium-scale farms, mainly animal draught and manual labour, low level of mechanisation (few exceptions: replanting / reseeding).
Market orientation: Mainly subsistence and mixed, but also commercial (e.g. Kenya and South Africa).
Land ownership and land use / water rights: In most cases individual land use rights and communal (organised).
Skill / knowledge requirements: Compared to other SLM practices medium to high, depending on the ICLM management practices applied e.g. if a stall-fed dairy unit is introduced. Land users need to undergo training programmes to learn how to best apply technology, including conserving the land, improving grazing and controlling invasive species. Keeping animals well-fed, healthy and productive needs a high level of skill.
Labour requirements: Medium to high labour requirements for stall-fed livestock with cut-and-carry and high for rehabilitation of grazing land through addition of species with structural and vegetative measures (e.g. for water harvesting). In this case labour requirements are mainly for the establishment phase.

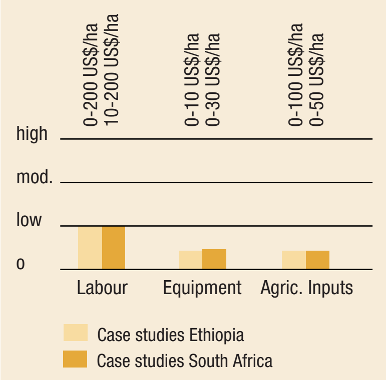


Economics

Established costs



Maintenance costs



(Source: WOCAT, 2009)

Labour costs in US$ are similar between ICLM technologies in Ethiopia and South Africa. In Ethiopia more manual and untrained labour, and in South Africa less but more qualified (therefore more expensive) labour is required.
Establishment costs can be relatively high for fencing materials, and increasing when reseeding / replanting, control of invasive species, water harvesting is added. Maintenance costs are generally low.
In the case of stall-fed livestock, initial costs are high both for purchase of animals and for buildings.
The costs per hectare for ICLM are relatively low compared to other SLM groups, however the generally lower productivity of grazing land compared to cropland, makes a comparison per hectare difficult.

Production benefits

Several studies carried out recently have clearly shown that integration of livestock with crops results in improvements of 50% (Ethiopian highlands) to over 100% (Zimbabwe) or more, in terms of farm productivity and income, compared to smallholders who only raise subsistence crops.
Approximately 25% of the agricultural domestic product in SSA is from livestock, not considering the contributions of animal traction or manure (Winrock International, 1992; in Pell, 1999). When traction and manure are included, livestock contribute 35% of the agricultural domestic product (Pell, 1999).

Benefit-Cost ratio

	short term	long term	quantitative
Fodder / crop / animal productivity	+	++/+++	No data available

– – negative; – slightly negative; –/+ neutral; + slightly positive; ++ positive; +++ very positive

The value of manure and animal traction equals in East Africa the value of meat, and Sub-Saharan Africa as a whole has the potential to increase the total gross value of livestock products by about a third. As mixed crop-livestock systems expand, the relative importance of animal traction and manure will grow (Ogle 1996).

Output	West Africa	Central Africa	East Africa	South Africa	Sub-Saharan Africa
	Percent of gross value of output				
Animal traction	21	3	39	26	31
Manure	4	1	3	2	3
Meat	56	79	38	58	47
Milk	11	12	17	9	15
Eggs	8	5	3	5	4

Example: Senegal
The Rodale Institute Regenerative Agriculture Research Centre in Senegal has worked closely with 2,000 farmers in 59 groups to improve soil quality, integrate stall-fed livestock into crop systems, add legumes and green manures, improve the use of manures and rock phosphate, incorporate water harvesting systems and develop effective composting systems. The result has been a 75-195 percent improvement in millet yields – from 330 to 600-1,000 kg/ha, and in groundnut yields from 340 to 600-900 kg/ha. Yields are also less variable year to year, with consequent improvements in household food security – clearly contributing to CC adaptation (FAO 2007).

Example: Kenya
In the semi-arid highlands of Kenya, water loss by runoff was over 80% of the rainfall due to bare ground. The fodder production was mainly annual grasses and forbs of low value. In a rotational grazing system with a ground cover of more that 40%, runoff was reduced to zero. The cover was mainly from perennial grasses and the production was between 4-8 times higher than on the overgrazed land. Furthermore, it was recorded that under acacia trees high value perennial grasses were preserved even in the overgrazed areas (Liniger and Thomas, 1998).

Impacts

Benefits	Land users / community level	Watershed / landscape level	National / global level
Production	+++ increased crop yield and quality +++ improved livestock nutrition and productivity ++ fodder production / quality increase ++ production diversification ++ providing energy through draft power and (sometimes) biogas	++ reduced risk and loss of production	+++ improved food and security
Economic	++ increased farm income + creation of job opportunities, spreading of labour + recycle resources, reduces need for chemical fertilizer (inputs)	++ stimulation of economic growth + diversification and rural employment creation + less damage to off-site infrastructure	+++ improved livelihood and well-being
Ecological	+++ increased soil fertility and organic matter (improved nutrient recycling) ++ improved soil cover ++ reduce soil erosion (by water / wind) ++ biodiversity enhancement ++ increase animal health + improved water availability + improved micro-climate	+ reduced degradation and sedimentation ++ intact ecosystem + increased water availability + increased water quality + reduced wind transported sediments	++ reduced degradation and desertification incidence and intensity ++ increased resilience to climate change ++ enhanced biodiversity
Socio-cultural	++ improved conservation / erosion knowledge ++ reduced workload (draft power) + improvement in household diets	+ increased awareness for environmental 'health' ++ attractive landscape ++ reduced rural-urban migration	+ protecting national heritage

	Constraints	How to overcome
Production	• Low nutritional value of crop residues • *Tsetse* fly in specific areas • Possibly more vulnerable to disturbances since livestock and crop production are interdependent	➜ supplement with fodder legumes, trees ➜ resistant breeds of livestock (stall-fed)
Economic	• 'Investment' costs can be rather high (e.g. fences, manure transport, seeds and seedlings) • Availability of inputs, e.g. labour and seeds, at times even tractors and implements • On larger scale fencing almost impossible	➜ establish credit and loan systems ➜ community mobilisation, self-help groups, government and project support and using family labour ➜ use thorn bush (encroachment) to make fence or social fencing
Ecological	• Competition for crop residues • Efficient use of biomass • Insufficient livestock and availability of animal manure • Burning of seed / seedlings by manure • Contamination of water by livestock • Increase of incidence by fire	➜ alternative sources e.g. other sources of animal feed ➜ keep animals in stalls; introduce cut-and-carry, initial reduction of stocking rates ➜ amend with green manure, N-fixing trees and / or supplement with chemical fertilizers ➜ modify and adapt mode of application ➜ introduce cut-and-carry, haymaking before grass is too tall and controlled grazing to reduce potential fuel material
Socio-cultural	• Insecurity of land tenure • Access to credit (e.g. veterinary services) • Possible dependence on experts concerning species selection (livestock and crop / feed) and planting methods • Lack of awareness and access to knowledge • More pressure on remaining grazing area (enclosures) • Rotational grazing can fail due to wrong timing • Weak governance and reluctance to observe the existing rules and regulations (lack of control) • Requires 'double' expertise (animal and crops)	➜ set appropriate land use policy ➜ credit schemes and land users associations ➜ create awareness ➜ use enclosures for cut and carry and hay making ➜ intelligent pasture management – knowing when to graze and when to rest ➜ install control and fining mechanism ➜ training and capacity building, strengthening advisory service

Adoption and upscaling

Adoption rate

The adoption rate depends on the specific ICLM system. Land users have basic traditional knowledge needed to integrate livestock and crop production, but because of their limited access to knowledge, assets and inputs – especially dairy cattle - relatively few adopt an upgraded integrated system.
Adoption of enclosures with cut-and-carry depends on availability of land for closure and availability of incentives. Spontaneous acceptance of this practice is relatively low and if it is practised then it is mainly with external support.
It is rare that the initiative is taken by the villages alone. The reasons are numerous inlcuding the decrease of production area, privatisation of land etc.

Upscaling

In semi-arid regions the transition in crop and livestock production from the current relatively extensive, low input/output production to more intensive, higher input/output production presents numerous challenges.

– participation of community right from the beginning, during planning to implementation, to ensure ownership
– availability of land and consensus of the community where the system can be introduced or applied
– secure land use rights and tenure
– need for training and capacity building in use of technology and its benefits
– need for training and support in animal husbandry
– requires change in mindset from 'focus on parts' towards 'the whole system'

Incentives for adoption

For regeneration of pastureland, where intensive structural measures are included, land users often rely on incentives (food-for-work or materials). If seedlings and seed are used, the community might need support to at least initiate their production (e.g. tree and seed nurseries). Where stall-fed dairy systems are put in place, it is common that projects supply an initial cow, and then they are 'repaid' with the first heifer calf.

Enabling environment: key factors for adoption	
Inputs, material incentives, credits	++
Training and education	++
Land tenure, secure land use rights	+++
Access to markets	++
Research	++
Participation (% involvement)	+++
Initial external support	++

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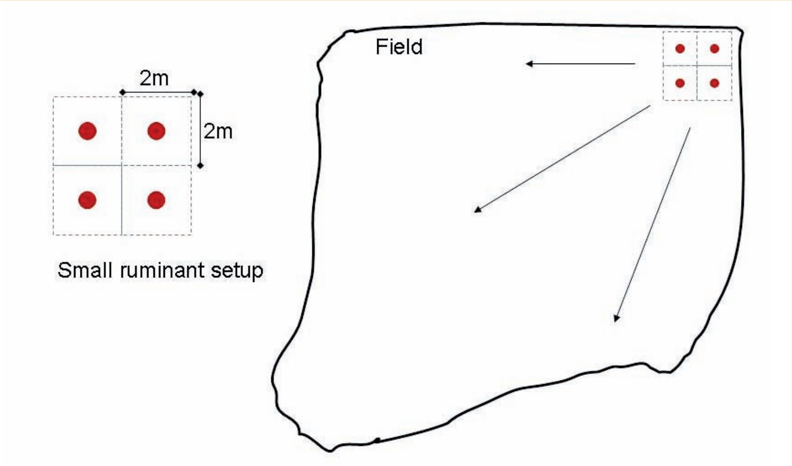
NIGHT CORRALLING - NIGER

Night corralling of cattle, sheep and goats on cropland during the dry season (November-April) replenishes soil fertility of agricultural land depleted by continuous cropping. This technology is mainly applied in semi-arid and subhumid areas on sandy / loamy plains with low soil organic matter content, low soil pH, and with slopes below 5%. Adequate spacing of animals helps to homogenously distribute the manure on the field (see photo): in cattle this is ensured through tying the animals to poles, in sheep and goats a movable fence serving as night enclosure helps to save labour.
Corals and animals are moved to a new spot within the field every 4-5 nights to homogeneously manure fields. Ideal is a rate of 2.5 tonnes of faecal dry matter per hectare. The application of this amount results in superior grain yields (millet, sorghum) as compared to an unmanured field. High yield response is achieved in the cropping season directly following the corralling (year 1) and in the subsequent two to three years, in which no new deposit of faeces and urine, i.e. no further corralling, is needed.
While a 250 kg cow deposits about 1 kg of manure dry matter per night, 7 sheep or 7 goats are needed to produce this same amount. Thus, to cover 1 hectare of land with 2.5 tonnes of manure, a herd of 15 cattle would need to be corralled during 167 nights; alternatively 178 nights would be needed if 70 small ruminants were corralled. Since individual herds are often smaller than 15 cattle (or 70 small ruminants) and fields are larger than 1 hectare, it is recommended to organise corralling of fields within a community (village) of farmers and especially to revitalise the traditional corralling contracts ('*contrats de parcage*') with transhumant herders.



SLM measure	Management and agronomic
SLM group	Integrated Crop-Livestock Management
Land use type	Agropastoral and cropland
Degradation addressed	Loss of soil fertility (organic matter, nutrients, pH decline) due to continuous cropping
Stage of intervention	Rehabilitation
Tolerance to climate change	Technology not much affected by climatic extremes or changes

Establishment activities

1. Purchasing the poles.

Maintenance / recurrent activities

In year 1 (of a 3-years cycle):

1. Placing poles in the field at 2m x 2m spacing for small ruminants and at 4m x 4m spacing for cattle, starting at the field border (see technical drawing).
2. Attach individual animals (adult small ruminants, adults or calves if you work with cows) to the pole during night.
3. Shift the poles to an adjacent unmanured part of the field every 4 days in cattle, and every 5 days in small ruminants. To cover the whole field (1 ha) with manure:
   – with 15 cattle you will need a total of 167 nights of corralling;
   – with 70 small ruminants you will need 178 nights.

In year 2 and 3 (of a 3-years cycle):

4. Cultivate the field for 3 subsequent cropping seasons (year of application, plus year 2 and 3) without further corralling in year 2 and year 3.
5. Apply a new corralling treatment in year 4 (repeat maintenance steps 1-4).

Labour requirements

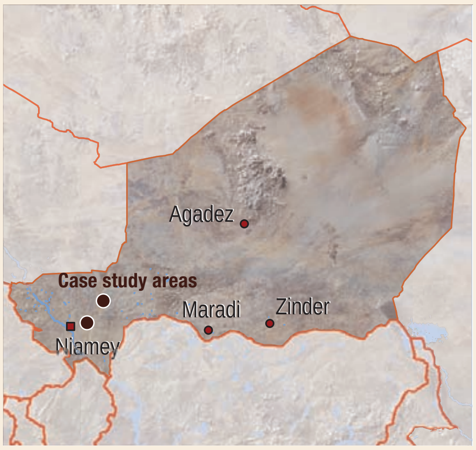
For establishment: low
For maintenance: low

Knowledge requirements

For advisors: moderate
For land users: moderate (spacing and timing of animal placement need to be respected)

Photo 1: Relatively homogenously manured field obtained through night corralling of cattle in south-western Niger. (Pierre Hiernaux)
Technical drawing: Corralling area of 4 sheep to poles (brown circles) during 5 nights (left) and principle of shifting corralling areas across a field of undefined size (right). (Eva Schlecht)

Case study area: Fakara region (near Niamey) and Chikal territory (near Filingué), Niger



Establishment inputs and costs per ha

Inputs (for 1 ha with 15 cattle)	Costs (US$)
Equipment: 15 poles (1 per animal)	15
TOTAL	**15**

Inputs (for 1 ha with 70 sheep)	Costs (US$)
Equipment: 70 poles (1 per animal)	70
TOTAL	**70**

Maintenance inputs and costs per ha per year

Inputs (for 1 ha with 15 cattle)	Costs (US$)
Labour: 1.3 person-days*	3
Equipment: 5 poles (replacement)	5
TOTAL	**8**

** 11 minutes on 167 days in year 1; 0 days in years 2–3*

Inputs (for 1 ha with 70 sheep)	Costs (US$)
Labour: 1.7 person-days*	4
Equipment: 21 poles (replacement)	21
TOTAL	**25**

** 14 minutes on 178 days in year 1; 0 days in years 2–3*

Remarks: Labour costs incur in a 3-years cycle: putting and changing the poles on a specific field is done in year 1, while in years 2 and 3 the respective field is cultivated, and no corralling takes place. Actual labour input for corralling in year 1 is 4–5 days (= 10–15 minutes during approx. 170 days), equivalent to US$ 10–13; maintenance costs given in the tables above refer to the average expenses of the whole 3-years cycle.

Benefit-cost ratio

Inputs	short term	long term
Establishment	slightly positive	positive
Maintenance	highly positive	positive

Remarks: Labour input in year 1 (dry season) pays through high yields in harvest seasons of years 1–3.

Ecological conditions

- Climate: semi-arid
- Average annual rainfall: 250-500 mm
- Soil parameters: well drained, sandy, shallow soils, low to very low soil fertility; low organic matter; low pH (< 4)
- Slope: mostly flat (0-2%), partly gentle (2-5%)
- Landform: mainly plains, partly pediments
- Altitude: 100-500 m a.s.l.

Socio-economic conditions

- Size of land per household: average land holding is 13 ha (near Niamey) and 10 ha (near Filingué)
- Type of land users: small-scale farmers
- Population density: no data
- Land ownership: mostly individual, titled
- Land use rights: individual for fields, communal for pastures
- Market orientation: mostly subsistence (self-supply), partly mixed (subsistence and commercial)
- Level of mechanisation: manual labour

Production / economic benefits

+++ Increased crop yield (in year 1 - 3; corralling only done in year 1)
++ Increased farm income

Ecological benefits

+++ Improved soil organic matter (medium term)
+++ Increased soil fertility
++ Increased water holding capacity
++ Reduced risk of soil crusting

Socio-cultural benefits

++ Revaluation of traditional knowledge
++ Community institution strengthening through rotational corralling of multiple-owner herds on individuals' fields
++ Revitalisation of ties with transhumant groups

Weaknesses

- Implementation constraint: organisation of rotational corralling is necessary to effectively manure fields of a village community; this needs skilful organisation.
- Need to invest in poles.
- High labour investment in year 1.
- Difficulty to revitalise trustful partnership with transhumant pastoral groups, as more and more crop residues are harvested and stored at the homestead (no dry season feed for mobile herds).
- Extensive consultation and coordination is needed if rotational (community) corralling or involvement of transhumant herders is necessary due to low animal numbers (<12 cattle, <50 small ruminants) at the level of individual households.

Adoption

Relatively high, but incomplete in the sense that homogeneity of dung application is lacking.

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ROTATIONAL FERTILIZATION - NIGER

Rotational fertilization is an integrated crop-livestock management measure practised by the agropastoralist *Peulh*. At intervals of 2-3 years they relocate with their livestock to a new area previously used for crop cultivation - where they install their temporary dwellings and improve soil fertility by applying farm-yard manure and other organic materials.

The rotation of temporary habitation areas leads to successive fertilization of the land. Livestock (cattle or small ruminants) are corralled or tethered in the rehabilitation area over-night. They feed on crop residues and emerging grasses after harvesting of the crops. Dung dropped within the coral area is collected and then distributed on the fields. The main criterion for site selection is the level of land degradation. The size of the area occupied is maximum 500 m^2, and depends on family size, herd size and on the quantitative and qualitative objectives of soil fertilization of the land owner.

In the years after settlement (after families move to a new location) the treated area is used for crop cultivation, and crop rotation / intercropping are practiced (e.g. millet / legumes) for increased and diversified production, improved pest control and fertility management.

The effectiveness of this technology has led to field-fertilization contracts between agropastoralists and sedentary farmers. The farmers offer post-harvest grazing rights to the agropastoralists who in turn fertilize the land and benefit from the access to the important weekly markets in the area where they can sell milk. In this case the agropastoralist families and their livestock split up after the rainy season: a part assures fertilization of the own land, the other part is in charge of fertilizing foreign land (during 3-4 months) before returning home.

SLM measure	Management and agronomic
SLM group	Integrated Crop-Livestock Management
Land use type	Cropland: temporarily: settlement area
Degradation addressed	Soil fertility decline; Soil erosion by water; Soil erosion by wind
Stage of intervention	Rehabilitation
Tolerance to climate change	Tolerant to temperature increase and reduction of vegetation period; sensitive to droughts, floods, wind storms and rainfall variability

Establishment activities

1. Identification of site where level of land degradation is high.
2. Level and clean the land.
3. Layout / disposition of infrastructure (dwellings, barns, corral, poles, poultry habitat) according to type and degree of land degradation.
4. Establishment of infrastructure.

Maintenance / recurrent activities

➜ On land being treated

1. On-going fertilization by applying farmyard manure and any kind of organic material accruing from daily human activities to the soil during 2-3 years.
2. Maintenance / re-location of huts to improve fertilization of land (after rainy season).

➜ On previously treated land:

3. Land preparation (ploughing, e.g. cowpea).
4. Cultivation of millet and legumes (‘*niébé*’) as intercrop or in the form of crop rotation.

Labour requirements

For establishment: high
For maintenance: low

Knowledge requirements

For advisory service: na
For land users: low

Photo 1: Dung dropped by animals feeding on crop residues; sheltered corrals in the background. (Pierre Hiernaux)
Photo 2: Millet growing on fertilized fields. (Adamou Kalilou)
Photo 3: Increased yields are an important impact of the technology: millet sold on village market. (Adamou Kalilou)

Case study area: Damari, Kollo district, Tillabéry region, Niger

Establishment inputs and costs per ha

Inputs	Costs (US$)
Labour: 100 person-days	150
Construction material: lumber and straw for hut	200
TOTAL	**350**
% of costs borne by land users	100%

Maintenance inputs and costs per ha per year

Inputs	Costs (US$)
Labour: 10 person-days	15
TOTAL	**15**
% of costs borne by land users	100%

Remarks: Establishment of housing infrastructure is done collectively, involving dozens of community members within less than a week. Construction material is taken from the woodlands; many parts are re-used after moving. While expenses are expressed in US$, in reality costs are in kind (mutual help) or not paid for (free lumber). Maintenance activities include: maintenance and re-building of dwellings. Costs for crop cultivation (US$ 335-535 annually) are not included.

Benefit-cost ratio

Inputs	short term	long term
Establishment	positive	very positive
Maintenance	positive	very positive

Remarks: The impact of the measure on soil productivity is increasing in the mid and long term.

Ecological conditions

- Climate: semi-arid
- Average annual rainfall: 400-550 mm
- Soil parameters: very poor sandy soils with low soil organic matter content, usually well drained (low in case of soil crusting)
- Slope: mostly flat (0-2%)
- Landform: mainly plains / plateaus, valley floors
- Altitude: 0-100 m

Socio-economic conditions

- Size of land per household: 1-2 ha
- Type of land users: groups / community, family; small-scale, poor
- Population density: 10-50 persons/km^2
- Land ownership: mostly individual, untitled
- Land use rights: individual, communal (organised)
- Market orientation: mostly subsistence (self-supply), partly mixed (subsistence and commercial)
- Level of mechanisation: manual labour

Production / economic benefits

+++ Increased crop yield
+++ Increased farm income
+++ Increased animal production
++ Increased fodder quality and fodder production

Ecological benefits

++ Increased soil cover
+++ Reduced wind velocity
+++ Increased soil fertility
++ Increased biomass / above ground carbon
+++ Reduced soil loss
+++ Increased animal diversity

Socio-cultural benefits

++ Conflict mitigation
+++ Community institution strengthening through mutual aid in technology implementation
+++ Improved cultural opportunities

Off-site benefits

+++ Reduced damage on public / private infrastructure
+++ Reduced damage on neighbours' fields
++ Reduced wind transported sediments

Weaknesses ➜ and how to overcome

- Growing costs and decreasing availability of timber and poles for establishment of infrastructure ➜ re-introduce traditional techniques of long term conservation of housing materials.
- High labour input for implementation ➜ reinforce community structures for mutual help.
- Area treated by the technology is too small regarding the area in need of treatment (degraded land) ➜ reinforce the solidarity between communities to increase the treated area.
- Negative effect on the woodland (*brousse tigrée*): cutting for building materials, clearing for cultivation ➜ identify new ecological materials for house construction; tree plantation.
- Marginalisation of families with low activity potential ➜ reinforce mutual help systems to support poor / small families.

Adoption

High spontaneous adoption of this indigenous technology. Its high effectiveness has helped spread the technology to adjacent areas on the other side of the river Niger, where farmers contract the agropastoralists for their 'fertilization service'. The area covered by the technology is approximately 1,500 km^2.

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GRAZING LAND IMPROVEMENT - ETHIOPIA

Grazing land improvement is based on enclosures and planting of improved grass and fodder trees to enhance fodder and consequently livestock production and simultaneously control land degradation. This case study focuses on the highly populated, humid highlands of Ethiopia where the little remaining grazing land areas are overused and under enormous pressure.

The technology involves a combination of management, agronomic and vegetative measures: fencing to exclude open access, application of compost to improve soil fertility, planting of improved local and exotic fodder species, including multipurpose shrubs / trees (including nitrogen fixing species) legumes, and the local *desho* grass (*Pennisetum pedicellatum*). *Desho* has a high nutritive value and ensures regular cuts. It is planted by splits, which have high survival rates and establish better than grasses which are seeded. Other grass seeds and legumes are mixed with fodder tree seeds and then broadcast. Legumes include alfalfa (*Medicago sativa*) and clovers in some cases. The area is permanently closed for livestock. Fodder is cut and carried for stall-feeding and once a year, grass is cut for hay, which is stored to feed animals during the dry season.

In the study area, the fenced and protected communal grazing land has been divided into small plots (<0.5 ha) and distributed to individual users for cutting hay, as an incentive to stimulate proper management. The government provides training, technical assistance, close follow-up, and some inputs for initial establishment.

SLM measure	Management, agronomic and vegetative
SLM group	Integrated Crop-Livestock Management
Land use type	Extensive grazing (before), silvopastoral (after)
Degradation addressed	Soil erosion by water; Fertility decline
Stage of intervention	Rehabilitation
Tolerance to climate change	Tolerant to rains with high intensity, storms

Establishment activities

1. Delineate the area to be conserved and establish a fence (deadwood).
2. Subdivision of protected (communal) land into individual plots of 0.3 – 0.5 ha.
3. Prepare seedlings in nurseries (grass splits and tree seedlings).
4. Prepare seedbed (with a hand hoe, partly with oxen plough).
5. Prepare compost / manure (ash, animal manure, leaf litter, soil, water).
6. Plant grass splits and tree / shrub species in lines and on conservation bunds; sow grass seed by broadcasting (early rainy season).
7. Compost application (one month after planting).
8. Weeding.

Maintenance / recurrent activities

1. Cut and carry grass and leaves to feed stall-fed animals (after 2-3 months growth, during rainy season, end of August).
2. A final cut for hay making is taken early in the dry season (end of October) when the grass has matured well.
3. Weeding.
4. Enrichment planting and gap filling (once a year), combined with application of compost / manure (mixed with soil).

Labour requirements

For establishment: high
For maintenance: low

Knowledge requirements

For advisory service: high
For land users: moderate

Photo 1: *Desho* grass and multipurpose trees established to increase productivity of grazing lands.
Photo 2–3: Cut and carry of grass for stall-feeding from improved pasture. (All photos by Daniel Danano)

Case study area: Chencha, Ethiopia

Establishment inputs and costs per ha

Inputs (for 1 ha with 15 cattle)	Costs (US$)
Labour	320
Equipment	22
Agricultural inputs	710
TOTAL	**1,052**
% of costs borne by land users	56%

Maintenance inputs and costs per ha per year

Inputs	Costs (US$)
Labour	35
Equipment	4
Agricultural inputs	87
TOTAL	**126**
% of costs borne by land users	100%

Remarks: Seedlings are given by the government for initial establishment. For further extension of area and replanting, the land users set up their own nurseries. After 2–3 years maintenance costs decrease substantially as the grass cover closes up and maintenance activities such as replanting and compost application are reduced or cease. The local daily wage is about US$ 0.70 a day.

Benefit-cost ratio

Inputs	short term	long term
Establishment	slightly positive	very positive
Maintenance	positive	very positive

Remarks: Milk production compensates for some of the high investment costs (previously, production was low).

Ecological conditions

- Climate: humid (local term: *wett dega*)
- Average annual rainfall: 1,000-1,500 mm
- Soil parameters: good drainage; mostly medium soil organic matter, partly low
- Slope: moderate (5-8%) to rolling (8-16%), partly hilly (16-30%)
- Landform: ridges and hillslopes, partly footslopes
- Altitude: mostly 2,000-2,500 m

Socio-economic conditions

- Size of land per household: < 1 ha
- Type of land user: small-scale farmers (individually), mainly poor land users, partly average level of wealth
- Population density: 200-500 persons/km^2
- Land ownership: state
- Land use rights: individual for cropland, usually open access (communally used) for grazing land, except for the case study area where the rights to rehabilitated grazing land are given to individuals
- Market orientation: subsistence (self-supply)
- Level of mechanisation: manual labour

Production / economic benefits

+++ Increased livestock production
+++ Increased fodder production and fodder quality
++ Increased income (selling animals and their products)
+ Increased wood production

Ecological benefits

++ Improved soil cover
+++ Increased soil fertility
+++ Reduced soil loss
+++ Increased soil moisture
+ Biodiversity enhancement

Socio-cultural benefits

+++ Improved household diets (milk), improved health
+++ Community institution strengthening
+++ Increased willingness of the national institution to assist and support organised farmer groups (i.e. community institutions)
+++ Improved conservation / erosion knowledge
++ Increased availability of livestock products on the market (lowers prices for the consumers)

Off-site benefits

+++ Reduced transported sediments
++ Reduced downstream flooding
++ Reduced downstream siltation
++ Increased stream flow in dry season

Weaknesses ➜ and how to overcome

- At the initial stage of establishment it is very labour intensive ➜ use of improved land preparation methods such as oxen ploughing.
- It is an expensive technology (availability of cash for inputs, particularly seedlings) ➜ produce seedlings of improved species and compost in backyards.
- Needs high fertiliser application ➜ focus mainly on organic fertilizers.
- High pressure on remaining grazing areas ➜ keep animals in stall (stable) or park, at least part of the day and during the night and introduce cut-and-carry more widely.

Adoption

The 50 households who accepted the technology in the initial phase, did so with incentives. They were provided with planting material and hand tools. The rate of spontaneous adoption is very high. At present over 500 households have taken up the technology and the total area covered is about 20 km^2.

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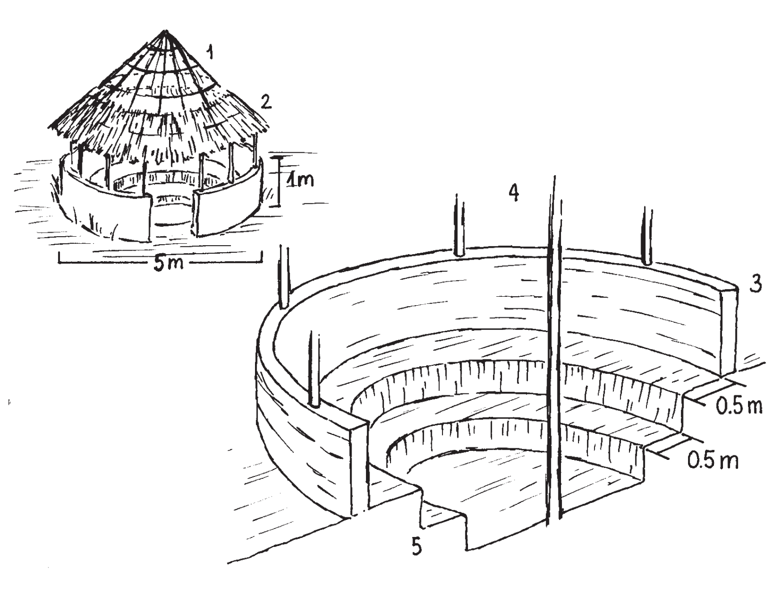
SMALLSTOCK MANURE PRODUCTION - TOGO

Smallstock manure production is an easy and efficient method to produce organic fertilizer for the conservation and improvement of soil fertility. The main item within this practice is the so-called *fosse fumière* - a 1-2 m deep and 3-4 m diameter circular pit, enclosed by a stone wall. The pit has a double function: it is the place where manure is produced and it serves as shed for small ruminants (goats, sheep), particularly to avoid uncontrolled grazing / browsing during the cropping season (from April until November). Animals are fed in the fosse, and they drop their faeces, which together with chopped organic material accruing from the kitchen and field activities, piles up in the pit for decomposition.

The fosse is partly roofed to provide optimal micro-climatic conditions: partial shading, partial exposure to sunlight and appropriate moistening through rainfall. Inside the pit, one or more circular terraces (0.5 m high, 0.5 m wide) serve as resting area for the animals. The terrace riser need to be plastered or reinforced with stones, particularly in case of loose soil, to avoid damage caused by animal trampling.

After decomposition the manure is removed from the pit and distributed on the fields beginning of each cropping season (March). Then straw bedding is renewed and the process starts from scratch. During the dry season from December to March smallstock is left to graze freely on the fields and pastures.



SLM measure	Management and agronomic
SLM group	Integrated Crop-Livestock Management
Land use type	Mixed: Agropastoralism
Degradation addressed	Fertility decline, reduced organic matter content
Stage of intervention	Mitigation and rehabilitation
Tolerance to climate change	Technology not much affected by climatic extremes or changes

Establishment activities

1. Delimitation of the perimeter of the pit and the position of the steps.
2. Excavation of the pit, shaping a terraced structure: 1-3 circular, 0.5 m high and 0.5m wide terraces.
3. Build up a stone wall around the pit, spaced at minimum 0.5 m from the pit, with an integrated gate.
4. Build a roof, which partly covers the pit.
5. Put straw on the ground and corral the animals.
6. After one year (April to March) the compost is ready for application on the field.

All activities carried out by manual labour.

Maintenance / recurrent activities

1. Continuous depositing and piling up of vegetative material (dung, kitchen waste, crop residues).
2. Let decompose the organic material inside the pit (during 1 year).
3. Twice a year (between April and November) the material is actively mixed for aeration.
4. Distribute the manure on the fields (during rainy season).

Labour requirements

For establishment: high
For maintenance: moderate

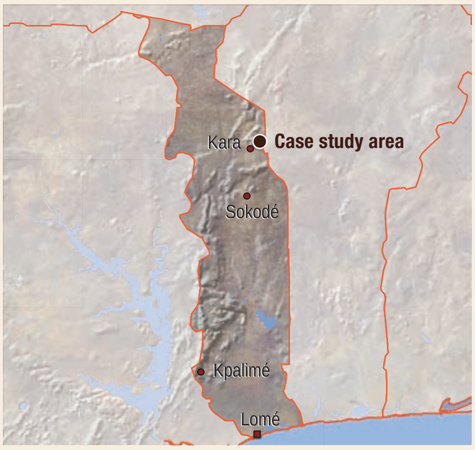
Knowledge requirements

For advisory service: moderate
For land users: moderate

The technology was early traditional and passed from father to son. It was improved in 1987.

Photo 1: Manure production with small ruminants. (Idrissou Bouraima)
Technical drawing: Dimensions and main components of a manure production pit: (1) open part of the roof; (2) covered part of the roof; (3) stone wall; (4) poles (holding the roof); (5) terraces (where animals can rest).(Mats Gurtner)

Case study area: Lassa, Kara, Togo



Establishment inputs and costs per ha

Inputs	Costs (US$)
Labour (36 person-days)	200
Equipment*	182
Agricultural inputs	0
TOTAL	**382**
% of costs borne by land users	100%

**poles, crossbars, stones / bricks, rope, etc*

Maintenance inputs and costs per ha per year

Inputs	Costs (US$)
Labour	150
Equipment	0
Agricultural inputs	0
TOTAL	**150**
% of costs borne by land users	100%

Remarks: Main cost-relevant factor is labour. Material such as stones and straw are available on the farm (no monetary costs).

Benefit-cost ratio

Inputs	short term	long term
Establishment	slightly positive	positive
Maintenance	slightly positive	positive

Ecological conditions

- Climate: subhumid
- Average annual rainfall: 1,000-1,500 mm
- Soil parameters: good drainage; low soil organic matter
- Slope: mostly flat (0-2%), some gentle (2-5%)
- Landform: mostly plateaus / plains, some footslopes
- Altitude: < 100 m a.s.l.

Socio-economic conditions

- Size of land per household: 1-2 ha
- Type of land users: small-scale farmers; average level of wealth, partly rich land users; technology implementation mostly done individually, sometimes in groups
- Population density: 300 persons/km^2 in the region
- Land ownership: individual, titled
- Land use rights: mostly leased, some individual
- Level of mechanisation: manual labour
- Market orientation: mainly mixed (subsistence and commercial), partly subsistence

Production / economic benefits

+ Increased crop yields
+ Increased farm income

Ecological benefits

++ Increased soil fertility / soil organic matter
+ Increased soil moisture

Socio-cultural benefits

++ Increased conservation / erosion knowledge
+ Improved food security

Weaknesses ➜ and how to overcome

- Manual construction is very labour-intensive ➜ mechanised excavation.
- Air pollution through smelly animal dung ➜ add products which attenuate the smell; establish the manure pit outside the residential area.
- Accident risk for children ➜ establish the manure pit outside the residential area.

Adoption

The technology covers an area of 0.15 km^2. All land users in the study area (totally 60) have adopted the technology voluntarily, without any external support other than technical assistance. There is a moderate trend towards further spontaneous adoption (about 60 %), depending mainly on the availability of livestock.

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