AGROFORESTRY


High diversity in an agroforestry system, Ethiopia. (Hanspeter Liniger)

In a nutshell

Definition: Agroforestry (AF) is a collective name for land use systems and practices in which woody perennials are deliberately integrated with agricultural crops and / or livestock for a variety of benefits and services. The integration can be either in a spatial mixture (e.g. crops with trees) or in a temporal sequence (e.g. improved fallows, rotation). AF ranges from very simple and sparse to very complex and dense systems. It embraces a wide range of practices: alley cropping, farming with trees on contours, or perimeter fencing with trees, multi-storey cropping, relay cropping, intercropping, multiple cropping, bush and tree fallows, parkland systems, homegardens etc.; many of them are traditional land-use systems. AF is thus not a single technology but covers the broad concept of trees being integrated into cropping and livestock systems in order to achieve multi-functionality. There is no clear boundary between AF and forestry, nor between AF and agriculture.

Applicability: On subhumid mountain slopes AF can be practiced on a whole farm as around Mt. Kilimanjaro (Chagga system) and Mt. Kenya (Grevillea system). In the drylands AF is rarely practiced on whole farms (except under parkland systems in the Sahel). It is more common for trees to be used in various productive niches within a farm. AF is mainly applicable to small-scale land users and in small-to large-scale tea / coffee plantations.

Resilience to climate variability: AF is tolerant to climate variability. AF systems are characterised by creating their own micro-climates, and buffering extremes (excessive storms or dry and hot periods). AF is recognised as a greenhouse gas mitigation strategy through its ability to sequester carbon biologically. The adaptation and mitigation potential depends on the AF system applied.

Main benefits: Agroforestry systems have great potential to diversify food and income sources, improve land productivity and to stop and reverse land degradation via their ability to provide a favourable micro-climate, provide permanent cover, improve organic carbon content, improve soil structure, increase infiltration, and to enhance fertility and biological activity of soils.

Adoption and upscaling: There is a lack of quantitative and predictive understanding about traditional and innovative agroforestry practices and their importance in order to make them more adoptable. Long term field research / monitoring are needed because of the complex nature of tree / crop systems.

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)	0.3 - 6.5*
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	++

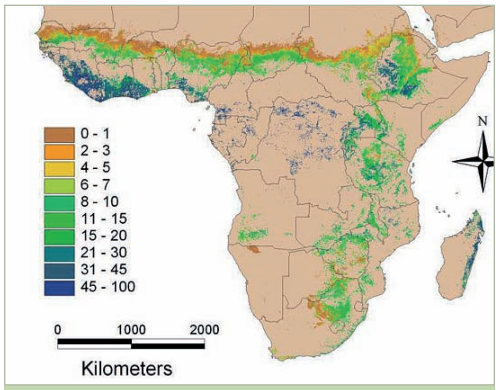
** for a duration of the first 20-30 years of changed land use management, depending on the selected tree species (Source: Nair et al., 2009)*

Origin and spread

Origin: AF encompasses many traditional land-use systems such as home gardens, boundary tree planting, shifting cultivation and bush fallow systems, contour cropping. AF is traditional and was 'rediscovered' in 1978 when the name 'agroforestry' was coined. Since then it has been promoted by projects and through land user's initiative. Alley cropping was conceived in the late 1970s by research to eliminate the need for a fallow period in the humid and subhumid tropics to replenish soil fertility.
Mainly applied in: Burkina Faso, Ethiopia, Guinea, Kenya, Lesotho, Malawi, Mozambique, Nigeria, Niger, South Africa, Tanzania, Togo, Uganda, Zambia, Zimbabwe: however all countries in SSA practise one form or another of AF. What differs is the extent, and the forms of AF practiced in these countries.

Principles and types

The factors influencing the performance of AF are crop, livestock and tree types and mixtures, germplasm, number and distribution of trees, age of trees, management of crops, livestock and trees, and the climate.
Agroforestry parkland systems are mainly cropland areas with dispersed trees (often indigenous). Among the characteristics of traditional agroforestry parklands are the diversity of tree species they contain and the variety of products and uses (including fruits, fodder, etc.). They generate and provide favourable micro-climates (through shade especially) and buffer extreme conditions (through acting as windbreaks). Parklands are found primarily in the semi-arid and subhumid zones of West Africa. *Faidherbia albida* / cereal systems are predominating throughout the Sahelian zone (e.g. 5 million ha in Niger) and in some parts of East Africa. For many local populations these systems are very important for food security, income generation and environmental protection.
Multistorey systems are defined as existing or planted stands of trees or shrubs that are managed as an upperstorey of woody plants and one to several understoreys of woody and non-woody plants that are grown for a variety of products. The purpose is (a) to use different layers and improve crop diversity by growing mixed but compatible crops of different heights in the same area; (b) protect soils and provide a favourable micro-climate; (c) improve soil quality by increasing utilisation and cycling of nutrients and maintaining or increasing soil organic matter and (d) increase carbon storage in plant biomass and soil. The Chagga homegardens of Tanzania, which integrate more than 100 plant species, provide a classic example of a multistorey AF system.
Fodder banks: Trees and shrubs with palatable leaves and / or pods are attractive to farmers as feed supplements for their livestock because they require little or no cash for inputs: they can be grown on boundaries as trees (often pollarded to reduce competition) or as hedges. They effectively do not compete for land as they are grown along boundaries, pathways - and along the contour to curb soil erosion. Managing fodder shrubs requires multiple skills including raising seedlings in a nursery, pruning trees, and feeding the leaves. This is a constraint to rapid spread of the technology. Nevertheless, over the past 10 years, about 200,000 farmers in Kenya, Uganda, Rwanda, and northern Tanzania have planted fodder shrubs, mostly to feed dairy cows.
Improved fallows consist of planted woody species in order to restore fertility within a short time. Traditionally fallows take several years. Natural vegetation is slow in restoring soil productivity. By contrast, fast growing leguminous trees and bushes - if correctly identified and selected - can enhance soil fertility by bringing up nutrients from lower soil layers, litter fall and nitrogen fixation. Improved fallows are one of the most promising agroforestry technologies in the subhumid and humid tropics and have shown great potential for adoption in southern and eastern Africa in recent years.
Windbreaks / shelterbelts are barriers of trees and shrubs that protect against damaging wind. They are used to reduce wind velocity, protect growing plants (crops and forage), improve micro-environments to enhance plant growth, delineate field boundaries, and increase carbon storage.



Tree cover on agricultural land in SSA
(Source: Zomer et al., 2009)

Top: Off-season onion gardens (background) in a parkland system, Burkina Faso. (Christoph Studer)
Middle: Intercropping of 4 different plant species, Rwanda. (Hanspeter Liniger)
Bottom: Agroforestry with grevilla trees, coffee, tea on steep mountain slopes, Kenya. (Hanspeter Linigier)

Applicability

Land degradation addressed

Chemical soil deterioration: declining soil fertility and organic matter content (due to continuous cropping and few inputs)
Erosion by water and wind: loss of fertile topsoil
Physical soil deterioration: compaction, sealing and crusting
Water degradation: namely high water losses by non-productive surface evaporation, extreme heavy events causing runoff and erosion

Land use

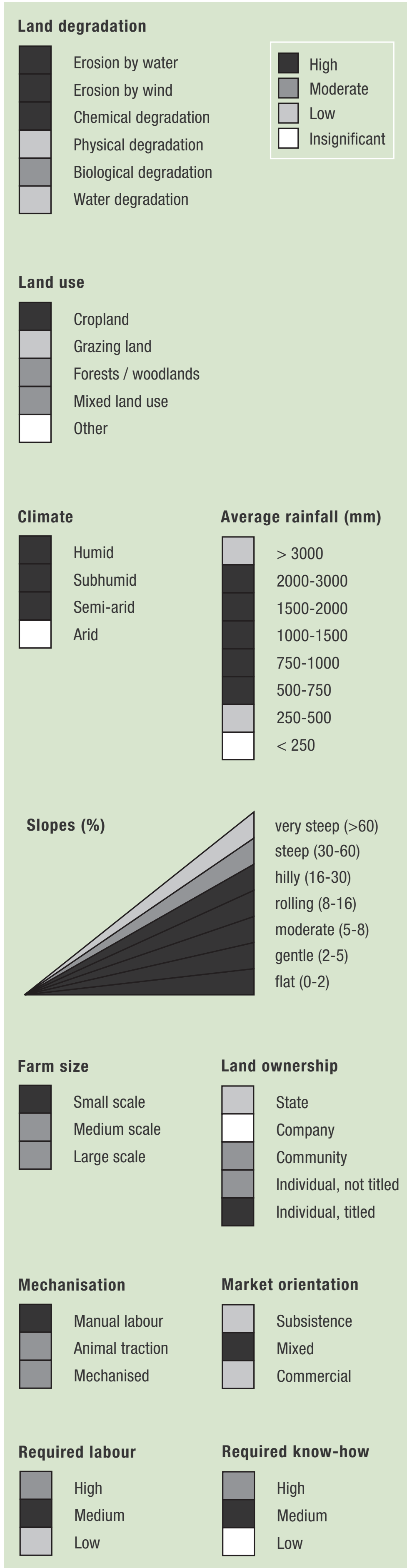
AF is suitable for all types of cropping systems where woody and non-woody species can be mixed. It is suitable for dry areas suffering from strong winds and wind erosion and low soil fertility (parkland systems, alley cropping and / or shelterbelts). Multistorey systems are suitable for areas with excessive rainfall causing erosion by water, soil compaction, expensive inputs especially fertilizers, pest and diseases.
Unsuitable for dry areas in situations where a lack of land (small farming units) makes AF systems such as parklands and improved fallows unsuitable. In more humid regions AF can be practiced on very small land parcels (e.g. Chagga homegardens; other multistorey systems). Unclear land and tree use rights are not favourable for the establishment of AF systems.

Ecological conditions

Climate: AF systems can be found in all kind of environments. Systems with low tree densities are more suitable in low rainfall areas and high density systems in high rainfall areas. AF in its diversity is suitable for a wide range of climates and AEZs. Parklands are not confined to specific AEZs and occur in various latitudes, but primarily in the semi-arid and subhumid zones of West Africa and in some parts of East Africa. Multistorey systems are more applicable in subhumid to humid environments or under irrigated systems, due to water requirements. Alley cropping and improved fallow have a wide range of applicability from semi-arid to humid.
Terrain and landscape: Suitable for all landforms and slopes: plains / plateaus as well as slopes and valley bottoms. Not suitable for high altitudes (higher than 2,000 – 2,500 m a.s.l) due to lower temperatures, negative impact of shade and a shorter growing season. AF is viable on steep land which otherwise is too steep for cropping: here AF can help building up terraces if trees are planted along the terrace risers.
Soils: No major limitations, AF is suitable for a wide range of soils. AF system can restore the soil fertility, where other land use systems have mined (depleted) soil nutrients.

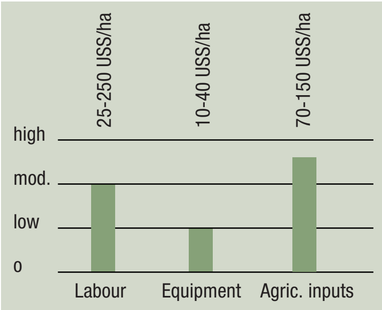
Socio-economic conditions

Farming system and level of mechanisation: Mainly applied on small-scale farms. However, it can be applied to all farm scales and conducted under different level of mechanisation (where trees are planted at low densities). In many countries women are the main actors in home gardening and food is mainly produced for subsistence.
Market orientation: Mainly applied in mixed systems (subsistence with some commercial). Can be applied in subsistence or commercial systems; access to markets is important to sell surplus production and for availability of inputs.
Land ownership and land use / water rights: Mostly applied on areas with individual land use rights and where land users have the rights to the trees they plant and tend. Communally owned land often lacks security of tenure and hence renders land users reluctant to practise and invest in agroforestry. Local regulations for the use of trees and crops are needed.
Skill / knowledge requirements: Medium to high and often part of a tradition, however selection of species suitable for different environments and purposes, as well as to minimise competition, needs know-how.
Labour requirements: Very variable, can be high for establishment – unless a system of protecting natural regeneration is used - but low for maintenance though some input needed for pollarding and pruning to reduce competition.

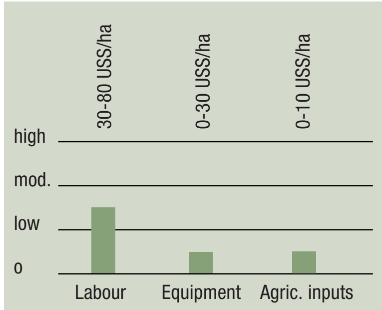


Economics

Establishment costs



Maintenance costs



Based on case studies from Ethiopia, Kenya and Togo (Source: WOCAT, 2009)

Establishment costs for agroforestry systems can vary a lot. Labour and agricultural inputs (seeds, seedlings, etc.) affect the establishment costs especially when linked to rainwater harvesting systems in drier areas.
Maintenance costs are relatively low.

Production benefits

	Yield without SLM (t/ha)	Yield with SLM (t/ha)	Yield gain (%)
Maize (Malawi)	0.7	1.5-2.0	110-190%

(Source: Malawi Agroforestry Extension Project; in Woodfine, 2009)

Comments: Crop yields can increase under an agroforestry system, however, AF does not lead in every case to an increase in crop production; depending on the type of system, the aggregate yield may improve as the products gained from the trees / shrubs compensate for any loss of crop yield.

Benefit-Cost ratio

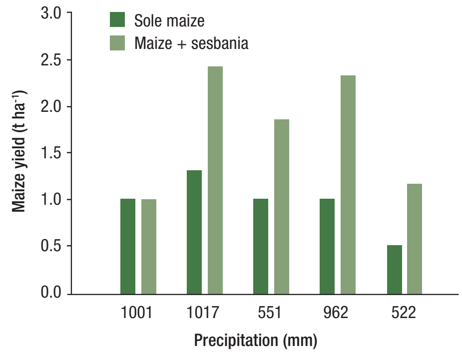
AF systems	short term	long term	quantitative
Parkland systems	–/+	+/++	No data available
Multistorey	+/++	+/++	
Alley cropping	+	++	
Improved fallow	++	+++	
Overall	+	++	

– – negative; – slightly negative; –/+ neutral; + slightly positive; ++ positive; +++ very positive
(Source: WOCAT, 2009)

Comments: Available benefit-cost analyses all point to the economic profitability of integrating trees within crop fields (particularly multipurpose tree species). Analyses have mostly only taken direct use values into account, because indirect use values, such as environmental functions, and non-use values such as cultural and religious functions are more difficult to evaluate. Furthermore, benefit-cost estimates are complicated by the many sources of annual variation in factors governing tree and crop production and tree-crop interactions.

Impact over different temporal scales is an issue that is especially relevant to agroforestry. Low-income land users more readily adopt agroforestry practices with short term benefits such as short term improved fallows (enriched with N-fixing bush / tree species) and multistorey systems.

Example: Malawi
Modeled maize grain yields in improved fallow rotations in Makoka, Malawi as a function of growing season precipitation.



(Source: Chirwa, 2003 in Verchot et al., 2007)

Example: Kitui district, Kenya
Within a study conducted in Kitui district, Kenya it was determined whether growing Melia volkensii trees in croplands was cost effective or not. The value of timber products gained with that of the crop value lost due to competition over an 11-year rotation were compared. Costs for seed, cultivation, tree planting stock or labour were not taken into account, which would increase the surplus of cash from the tree products because in recent years, crop failure has occured 50% of the time. It was shown that at the end of the rotation, the accumulated income from tree products exceeded the accumulated value of crop yield lost through competition by US$ 10 or 42% during average years and US$ 22 or 180% with the assumption of 50% crop failure due to drought. (In this district of Kenya, on average six of the 16 cropping seasons have failed) (Ong et al., 1999 in Verchot et al., 2007).

Example: Kenya, Uganda, Rwanda, and northern Tanzania
In the highlands of East Africa farmers with 500 calliandra shrubs increased their net income by between $US 62 to 122 depending on whether they used shrubs as a substitute, or as supplement, and depending on where they are located. Fodder shrubs are very attractive to farmers because they require little or no cash, nor do they require farmers to take land out of production for food or other crops (Franzel and Wambugu, 2007).

Impacts

Benefits	Land users / community level	Watershed / landscape level	National / global level
Production	+++ crop diversification ++ higher combined yields (trees, crops and livestock) ++ provide products year around	+++ reduced risk and loss of production ++ access to clean drinking water ++ reliable fuel wood supply	+++ improved food and water security
Economic	++ generate additional cash income	+++ less damage to off-site infrastructure + creation of employment + stimulation of economic growth	+++ improved livelihood and well-being
Ecological	+++ improved soil cover +++ reduced soil erosion (by water / wind) +++ favourable changes in micro-climatic conditions (e.g. shade trees (can reduce temperature extremes by approximately 5°C, windbreaks) ++ improve soil fertility and biological activity ++ improve organic carbon content (above and below ground) ++ more effective use of available water ++ enhanced biodiversity and soil life ++ improve soil structure + biocontrol of pests and diseases	+++ reduced degradation and sedimentation ++ increased water availability ++ improved water quality ++ intact ecosystem	+++ increased resilience to climate change +++ enhanced biodiversity ++ arresting and reversing land degradation
Socio-cultural	++ improved conservation / erosion knowledge ++ multipurpose tree, meeting various needs ++ reduces pressure on forests + community institution strengthening + social services (as boundary markers) + aesthetic value	++ increased awareness for environmental health ++ reduced conflicts due to reduced negative off-site impacts ++ attractive landscape ++ reduced deforestation	+++ protecting natural and national resources for the next generations (heritage)

	Constraints	How to overcome
Production	• Systems produce multiple products under specific conditions: some single products can suffer due to competition	➜ minimise competition and emphasise the overall production
Economic	• Labour and time consuming • High input demand • Reduced flexibility to changing markets related to tree products	➜ participation of all family members ➜ maximum use of locally available inputs: including indigenous tree seedbanks
Ecological	• Competition between trees (parkland, windbreaks, alley cropping) and crops for light, water and nutrients • Interception of rain by canopy • Loss of land for non-woody crops • Depleting groundwater (when scarce groundwater) • Dry periods result in low seedling survival rates • Timber susceptible to pest attack	➜ species selection and canopy management for reducing above and below ground competition (e.g. pruning of tree branches, periodic root pruning) ➜ with water harvesting and moisture management techniques, the technology could spread to lower rainfall areas ➜ increase the productivity of land per unit area, regular pruning of woody bush and trees esp. during the crop growing period ➜ species selection ➜ supplement with water harvesting and moisture management techniques ➜ species selection, integrated pest management, breeding of more pest tolerant varieties
Socio-cultural	• Forest policies hindering planting, use and ownership of trees • Physical and social barriers to smallholder participation in markets • The overall lack of information at all levels on markets for agroforestry products • Seedling availability and survival low	➜ e.g. charcoal policy reform and rights to trees; contract fuelwood schemes ➜ novel market information systems (e.g. per cell phones); facilitating and capacity building of farmer and farm forest associations ➜ collaboration between the private sector, research and extension ➜ small-scale nursery enterprises encourage local seed collection

Adoption and upscaling

Adoption rate

The complex management requirements of agroforestry (AF) may limit its adoption. Agroforestry systems, such as improved fallows, found widespread acceptance and adoption by smallholder farmers in Southern Africa (e.g. Zambia). In regions such as the highlands of East Africa, AF systems have spread with very little or no support from the outside, as land users value trees for multiple purposes and have strong motivation to plant and maintain good tree cover. 'Fertilizer tree species' (making nutrients available from deeper soil layers) tend to be adopted to a greater extent by the poorest families in the villages, which is unusual for agricultural innovations. Recently, with improved rainfall, secured rights to trees and project support, there has been a massive increase in parkland systems in the West African Sahel.

Upscaling

Parklands, for example, were developed by farmers over many generations to diversify production for subsistence, and for income generation, as well as to minimise environmental risks related to the high climatic variability in the region. This knowledge and tradition needs to be tapped and built upon in order to upscale AF. Understanding the system and how it works in different environments is also crucial. A knowledge system is needed that documents experiences and facilitates exchange between practitioners and scientists from different countries, and stimulates better understanding of the processes behind upscaling. Land users need more information and training to be able to adopt and implement AF systems suitable for their specific environmental conditions, as compared to other agricultural activities. This limits the spread of some AF techniques. Extension strategies, including field schools, exchange visits and farmer training, are effective ways of disseminating information.

Incentives for adoption

Both ecological and social factors are simultaneously important in motivating land users to grow trees on their farms. Land users as observed do accept yield losses provided the new intervention results in a clear return on investment. In the traditional parklands of West Africa, dense shading by shea nut trees (*Vitellaria paradoxa*) and *néré* (*Parkia biglobosa*), which reduce millet yield by 50–80% are used because of the high economic returns from marketable tree products. Markets for multipurpose tree products are crucial for the adoption of AF on a scale to have meaningful economic, social and environmental impacts. Land tenure reforms and established systems of payment for ecosystems services (PES) will encourage land ownership and stimulate the development of plantations (both forest and AF parklands). A stronger AF focus in agricultural policy and extension services and the promotion of markets and improved processing of AF products will encourage the adoption. Incentives provided are often in relation to building up tree nurseries at the village level.

Enabling environment: key factors for adoption	
Inputs, material incentives, credits	+
Training and education	++
Land tenure, secure land use rights	++
Access to markets (niche markets and high value products)	++
Research	++
Infrastructure	+

Example: Kenya, Uganda, Rwanda, and northern Tanzania

The spread of fodder shrubs in East Africa has been substantial. By 2006, about 10 years after the dissemination began, 224 organisations across Kenya, Uganda, Rwanda, and northern Tanzania were promoting fodder shrubs, and over 200,000 farmers had planted them, even though the number of shrubs per farm was still well below the number needed to feed a single dairy cow. The reason for the still rather low number of shrubs is that many farmers adopt incrementally - they first want to see how it performs, and many farmers 'partially adopt' applying several different strategies for providing fodder supplements to ensure better risk management. Due to the information-intensive nature of the technology, it does not spread easily on its own and thus requires outside facilitation. Considerable investments are required to reach other dairy farmers and sustain the uptake process (Franzel and Wambugu, 2007).

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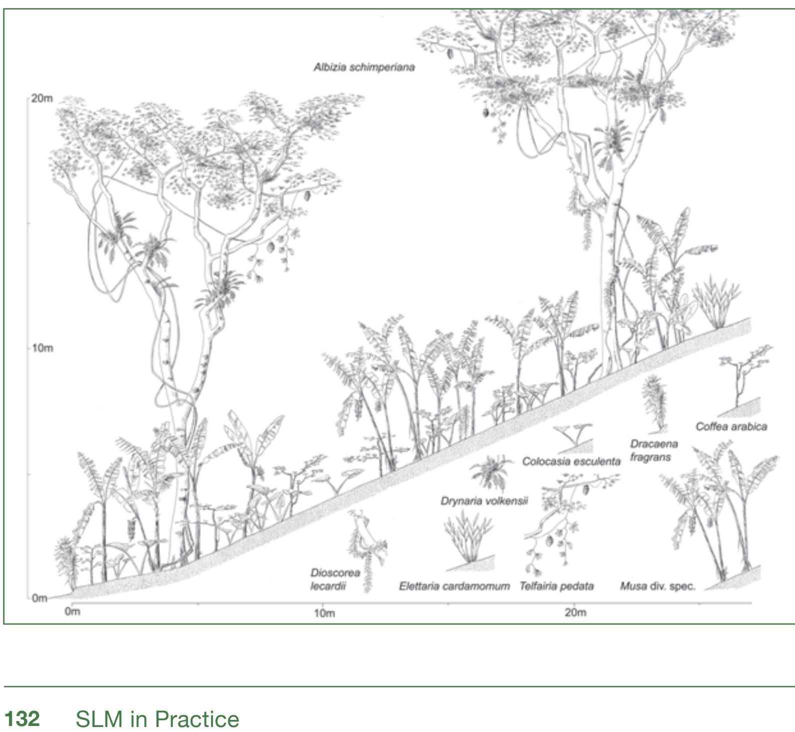
CHAGGA HOMEGARDENS - TANZANIA

The Chagga homegardens are traditional, densely planted 'banana forests' with a scattered upper tree layer. The complex multicropping system evolved over several centuries through a gradual transformation of the natural forest on the footslopes of Kilimanjaro. A Chagga homegarden has an average size of 0.68 ha and integrates numerous multipurpose trees and shrubs with food crops, and stall-fed animals, without a specific spatial arrangement. However, vertically, the following 4 stories / canopies can be distinguished: (1) food crops: taro, beans, vegetables and fodder herbs / grasses; (2) coffee: 500-1,400 plants/ha; (3) banana: primary crop; 50% cover; 330-1,200 clumps/ha; and (4) trees, such as *Cordia abyssinica*, *Albizia schimperiana* and *Grevillea robusta*. The trees provide shade for coffee, act as live fences, provide medicines, firewood, fodder, mulching material, bee forage; and some have pesticidal properties (e.g. *Rauwolfia caffra*).

This multilayer system maximises the use of limited land in a highly populated area, making sustained production possible with a minimum of external inputs, minimises risk (less production failure, increased resistance against droughts and pests) and ensures at the same time environmental protection. The large species diversity provides both subsistence and cash crops.

Parts of the homegarden area are irrigated and drained by a network of over 1,000 canals and furrows tapping runoff from the montane forest. However, many systems are now in disrepair. Starting in the 1930s when coffee took more space from the food production, it became necessary to expand food production to the lowlands. Today, the Chagga highland homegarden works only in combination with a lowland field where maize, millet, beans, sunflower and groundnuts are grown to ensure food security.



SLM measure	Management and vegetative
SLM group	Agroforestry
Land use type	Mixed (Agroforestry)
Degradation addressed	Nutrient depletion; Loss of topsoil
Stage of intervention	Prevention
Tolerance to climate change	Tolerant to climatic extremes: the system has a high buffer capacity (micro-climate, biodiversity, irrigation)

Establishment activities

1. Transforming the native forest: trees that provided fodder, fuel, fruits, medicines, shade, timber, bee forage, anti-pest properties are retained while the less useful species are eliminated.
2. Introduction of new fruit and timber tree species, such as avocado, mango, *Grevillea robusta*, *Persea americana.*
3. Planting crop species (banana, coffee, taro, beans, vegetables).
4. Establishment of irrigation / drainage channels.
5. Terracing or building of bunds in steep places.

Spatial arrangement of components is irregular and appears haphazard with the trees / shrubs and food crops intimately mixed.

Maintenance / recurrent activities

1. Planting, tending and harvesting of bananas, taro, yams (all year round).
2. Opening up the canopy to ensure better fruiting of the coffee.
3. Spacing out the banana stools.
4. Manuring crops (using dung from the stall-fed livestock and compost).
5. Lopping fodder trees / shrubs.
6. Pruning and spraying against coffee berry disease and leaf rust.
7. Maintaining irrigation furrows.
8. Coffee harvest (August-January).
9. Tending and milking the stall-fed cows (typically only one cow).
10. Mulching, terrace maintenance (soil erosion prevention in general).

All operations are performed manually.

Labour requirements

For establishment: medium
For maintenance: medium

Knowledge requirements

For advisors: medium to high
For land users: medium to high

Photo 1: Chagga homegardens with the snow-capped peak of Mt. Kilimanjaro in the background. (Hanspeter Liniger)
Profile: Typical chagga homegarden on a 45% slope at 1,400 m a.s.l. with 4 vegetation layers: open light upper canopy with *Albizia schimperiana* (up to 20 m high); upper shrub layer with banana (4-6 m); a lower shrub layer with coffee (1.5-2 m) and food crops such as taro (< 1.5 m) (Hemp A., Hemp C. 2009)

Case study area: Mt. Kilimanjaro Region, Tanzania

Establishment inputs and costs per ha

Inputs	Costs (US$)
Labour	na
Equipment	na
Agricultural inputs	na
TOTAL	**na**

Maintenance inputs and costs per ha per year

Inputs	Costs (US$)
Labour	300
Equipment (axes, hoes, pangas)	45
Agricultural inputs	100
TOTAL	**445**
% of costs borne by land users	100%

Remarks: Chagga homegardens are traditional systems which evolved over centuries through a gradual transformation of the natural forest into agroforestry gardens. Establishment of new gardens is not possible due to land shortage.

Benefit-cost ratio

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

Adoption

Locally well adopted traditional land use system, covering an area of approximately 1,200 km^2; further spread at local level is not possible due to land shortage. Migration of young people to urban areas leads to labour shortages and disrupts intergenerational knowledge transmission, required for the successful management and perpetuation of the homegardens.

Ecological conditions

- Climate: subhumid (tropical montane; bimodal: long rains in March-May, short rains in Nov-Dec)
- Average annual rainfall: 1,000-2,000 mm (depending on slope orientation and altitude)
- Soil parameters: fertile volcanic soils with a high base saturation and cation exchange capacity
- Slopes: hilly to steep (16 - 60%)
- Landform: Mountain slopes, orientation south / south-east
- Altitude: 1,000-1,800 m a.s.l.

Socio-economic conditions

- Size of land per household: 1-2 ha (2-3 separate plots)
- Type of land user: poor small-scale farmers
- Population density: 650 persons/km^2
- Land ownership: individual, traditional clan regulations (land cannot be sold to outsiders)
- Land use rights: individual
- Market orientation: mixed (subsistence and commercial)
- Level of mechanisation: manual labour

Production / economic benefits

+++ Continuous and diversified production: 185 kg beans/ha; 410 kg coffee/ha; 400 bunches of banana/ha; ca. 30 kg honey/ha
+++ Reduced risk of crop failure
++ Increased fuelwood production 1.5-3 m^3/ha/year
++ Valuable gene pool (for breeding programmes to improve crop varieties for multistorey cropping systems)
++ Increased labour efficiency

Ecological benefits

+++ Improved continuous ground cover
+++ Improved micro-climate
+++ Improved soil conservation and reduced soil loss
+++ High biodiversity and genetic variability (over 500 plant species including 400 non-cultivated plants)
++ High pest resistance

Socio-cultural benefits

+++ Improved food security
+++ Improved health
+++ Preservation of traditional knowledge

Weaknesses ➜ and how to overcome

– Productivity of Chagga homegardens is not optimal ➜ (1) Replace the less productive trees / shrubs with fast growing nitrogen fixing species (2) improve animal husbandry (e.g. to increase lactation period); (3) improve apiculture; (4) introduce new crop varieties using the gene pool developed by natural and farmer selection; (5) use fertilisers; (6) improve coffee production: certified production (organic, fair trade) to fetch higher prices; (7) replace old coffee plants with new ones; (8) integrated pest management; (9) facilitate access to capital for farm investments; (10) improve erosion control (terraces and bunds); (11) include productive fruit trees; (12) improve advisory services.
– Water management causes nutrient loss in the gardens and water shortages on the lower slopes ➜ improve efficiency of furrows: Install pipes and surfacing by cement, protect river banks from cultivation.
– High demand of wood, low coffee prices and the introduction of sun-tolerant coffee varieties endanger the homegardens ➜ incentive-based tree planting in gardens to reduce the pressure on the forest.

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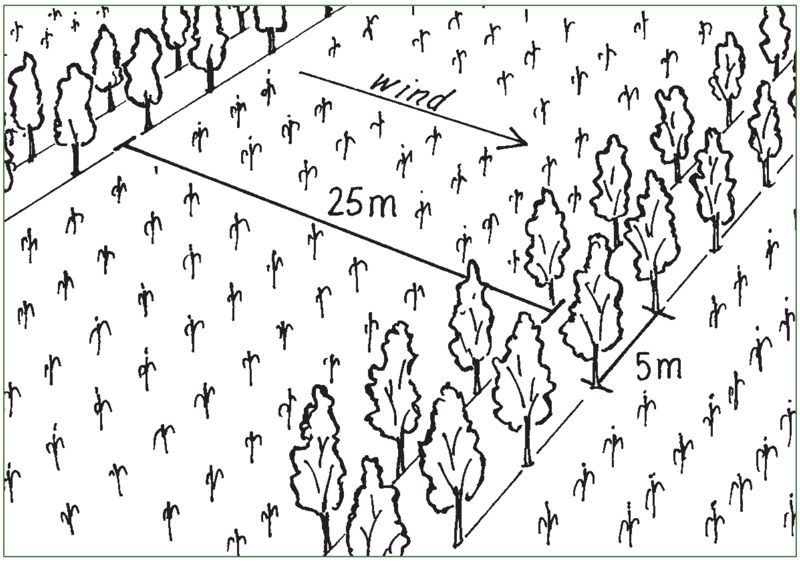
SHELTERBELTS - TOGO

On the vast denuded plains of Pays Kabyé in northern Togo, barriers of leguminous trees (e.g. *Cassia siamea* or *spectabilis*; a medium sized tree growing between 10-20 m tall; *Albizzia procera*, *Leucaena leucocephala*) and shrubs (*Cajanus cajan, Erythrina variegate*) are established between fields cultivated with annual crops such as maize. The shelterbelts provide a good microclimate and protect the crops against the counterproductive effects of wind speed such as wind erosion, soil moisture loss through evaporation and physical damage to crops.

The shelterbelts' effectiveness depends on their permeability, their spacing and the direction of planting in relation to the wind direction: A proportion of 40-50% of holes (openings, void) in relation to the total surface of the shelterbelt is desirable, and establishment of tree rows perpendicularly to the main wind direction is most effective. In order to reduce lateral turbulence the windbreaks need to reach a length of minimum 10 times their height. Shelterbelts protect 15-25 times their height on the leeward and 1-2 their height on the windward side. If the area to be protected is large, several windbreaks need to be established.

The denser the shelterbelts are, the better the windbreaking effect, but the higher the competition with crops for nutrients, light and water. Frequent pruning helps to avoid too much competition and provides fuelwood. In case leguminous tree species are used, soil properties can be improved through nitrogen fixation and the provision of organic matter (leaves).



SLM measure	Vegetative
SLM group	Agroforestry
Land use type	Cropland / mixed land
Degradation addressed	Wind erosion, Aridification
Stage of intervention	Prevention and mitigation
Tolerance to climate change	No data

Establishment activities

1. Determine the area to be protected and alignment of shelterbelts (1,2, or 3 lines of trees per row); rows to be established perpendicular to main wind direction; spacing between rows: 20-25m).
2. Establish plant nursery.
3. Dig planting pits at a spacing of 2-3 meters.
4. Planting of seedlings (when conditions are favourable).
5. Regular irrigation of young tree seedlings after plantation.
6. Weeding.
7. Reduce density to a spacing 5 m between trees.

All activities carried out during rainy season, using hand tools such as hoe, machete and measuring tape. Establishment takes 36 months.

Maintenance / recurrent activities

1. Weeding (according to necessity / speed of regrowth).
2. Pruning to avoid shading effect on crops.

Labour requirements

For establishment: high
For maintenance: moderate

Knowledge requirements

For advisors: high
For land users: moderate

Photo 1: A windbreak with two or three tree lines planted 5 m apart established between fields of annual crops. (Idrissou Bouraima)
Technical drawing: Spacing between windbreak rows is 20-25 m. The row of windbreak can be of a single tree line, of double tree lines, etc. depending on wind speed and scope of protection. The in between tree line spacing is 5 m. Plant density can range from 100 – 200 plants/ha depending on the number of tree lines planted within a windbreak. (Mats Gurtner)

Case study area: Tchitchao, Kara, Togo

Establishment inputs and costs per ha

Inputs	Costs (US$)
Labour	200
Equipment	86
Agricultural inputs	90
TOTAL	**376**
% of costs borne by land users	100%

Maintenance inputs and costs per ha per year

Inputs	Costs (US$)
Labour	139
Equipment	
Agricultural Inputs	23
TOTAL	**162**
% of costs borne by land users	100%

Remarks: The monetary costs include the purchase of seeds, cuttings or nursery plants and labour for the preparation and planting. In certain circumstances, it is necessary to protect young trees against browsing and other damage.

Benefit-cost ratio

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

Ecological conditions

- Climate: subhumid
- Average annual rainfall: 1,000-1,500 mm
- Soil parameters: medium to good drainage; shallow, sandy-loamy soils; medium soil organic matter
- Slope: gentle (2-5%)
- Landform: footslopes, plateaus / plains, hill slopes
- Altitude: 100-500 m a.s.l.

Socio-economic conditions

- Size of land per household: 1-2 ha
- Type of land user: small-scale farmers, relatively rich (about 1.5% of land users). Windbreak technology is little known by most farmers
- Population density: 300 persons per km^2 in the region
- Land ownership: individual, titled
- Land use rights: individual
- Level of mechanisation: no data
- Market orientation: subsistence and commercial

Production / economic benefits

++ Increased income from agriculture
++ Increased wood production and forest products (fruits)
++ Increased crop yield

Ecological benefits

++ Reduced wind speed
++ Reduced loss of topsoil (through wind erosion)
++ Reduced loss of soil moisture (through evaporation)

Socio-cultural benefits

++ Increased conservation / erosion knowledge

Socio-cultural benefits

++ Reduced off-site deposition of wind sediments

Weaknesses ➜ and how to overcome

- Reduced area for cultivation of crops ➜ establish the minimum of shelterbelts necessary for optimal protection.
- Reduced crop yields alongside shelterbelts (competition for nutrients, light, water) ➜ avoid dense planting of trees and shrubs; frequently prune the trees.
- Shelterbelts provide habitat for vermins / pests (rats, insects) ➜ frequently hunt these animals.
- Increased labour inputs.

Adoption

100% of the families who have implemented shelterbelts in the case study area have done it without any external support apart from technical advice. However, there is no growing trend of spontaneous adoption in the region since the windbreak technology is little known by most farmers.

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GREVILLEA AGROFORESTRY SYSTEM - KENYA

While *Grevillea robusta* (the 'silky oak', an Australian native) was originally introduced from India to East Africa as a shade tree for tea and coffee estates, it is now more commonly used in small-scale farming areas, especially in association with annual crops (maize / beans). There are three major forms of grevillea agroforestry systems: (1) planting along farm boundaries; (2) scattered grevillea trees on cropland - resembling open forests with multi-storey layers; (3) 'alley cropping' on terraces. Boundary planting is the most common form and is described in this case study.

Grevillea can be easily established and is relatively free of pests and diseases. The trees are managed through periodic pollarding – the pruning of side branches while maintaining the trunk – to reduce competition with crops. Competition is little in any case, and can be further reduced by digging a small trench around the trees, thus cutting the superficial roots.

Grevillea is planted for a number of purposes, including marking property boundaries, supplying fuelwood and building materials (pruning of side branches which rapidly regrow), providing shade and for ornamental value. Simultaneously it increases organic matter, provides mulching materials to improve ground cover, reduces wind speed, and encourages nutrient recycling due to its deep rooting. It can be planted over a wide range of agroecological zones and from sea level up to 2,000 metres. It is ideally suited to intensive areas of small-scale mixed farming. To effectively combat soil erosion problems on slopes, grevillea planting must be combined with additional measures such as *fanya juu* and bench terraces, grass strips and other vegetative and agronomic measures.

SLM measure	Vegetative
SLM group	Agroforestry
Land use type	Mixed (crops and trees)
Degradation addressed	Soil moisture problem; Fertility decline, reduced organic matter content; Loss of topsoil through water erosion
Stage of intervention	Mitigation
Tolerance to climate change	High tolerance to change of temperature and rainfall – Grevillea grows under a high range of climates

Establishment activities

1. Dig planting pits (before rainy seasons).
2. Purchase seedlings from nurseries or collection of wildings (naturally generated seedlings).
3. Plant seedlings (at onset of rains), initial spacing ca. 1 m, later thinned to 1.5 – 3 m.

Maintenance / recurrent activities

1. Weeding around seedlings when necessary (rainy season).
2. Pruning as necessary; pruned branches are dried and used for fuelwood (annually).
3. Pollarding (pruning of side branches; ensures large and straight tree trunks): annually, after crop harvest.
4. Root pruning: dig a trench (60 cm from tree, 25 cm deep) and cut the shallow roots to reduce competition with annual crops every four years.
5. Felling some trees to reduce density as they grow bigger (during dry season).
6. Replanting when trees are harvested for timber.

All activities carried out by manual labour using machetes (panga), hoes and handsaws.

Labour requirements

For establishment: moderate
For maintenance: moderate

Knowledge requirements

For advisors: moderate
For land users: low

Photo 1: Boundary planting of grevillea trees between smallholder plots used for cultivation of maize and beans.
Photo 2: Detailed view of a dense row of grevillea trees.
Photo 3: Scattered grevillea trees planted as a shade tree in a coffee plantation. (All photos by Hanspeter Liniger)

Case study area: Kiawanja, Nembure division, Embu, Kenya

Establishment inputs and costs per ha

Inputs	Costs (US$)
Labour	25
Equipment	10
Agricultural inputs	125
TOTAL	**160**
% of costs borne by land users	100%

Maintenance inputs and costs per ha per year

Inputs	Costs (US$)
Labour	65
Equipment	0
Agricultural inputs	25
TOTAL	**90**
% of costs borne by land users	100%

Remarks: Boundary planting is the basis of costing (assuming average plot size of 25 m by 25 m and an average spacing of 1 m between trees = 1,000 trees/ha). 1 person plants 50 trees in one day. The labour required for management (pruning and pollarding) of established trees is high. Seedling purchase price is also high, but this can be reduced by collecting wildings (seedlings growing in the wild) and establishing personal or group nurseries.

Benefit-cost ratio

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

Adoption

All land users of the catchment (totally 120 families) have accepted the technology spontaneously.

Ecological conditions

- Climate: subhumid
- Average annual rainfall: 1,000-1,500 mm
- Soil parameters: good drainage, deep well drained nitosols; soil organic matter mostly low and partly medium
- Slope: mostly rolling to hilly (8-30%), partly steeper
- Landform: ridges, mountain / hill slopes; also foot slopes / valleys
- Altitude: 1,000 – 1,500 m a.s.l.

Socio-economic conditions

- Size of land per household: mainly 1-2 ha, partly <1 ha
- Type of land user: mainly small-scale farmers
- Population density: > 500 persons/km^2
- Land ownership: individual titled
- Land use rights: individual
- Level of mechanisation: manual labour
- Market orientation: mixed (subsistence and commercial): marketed products include: grevillea timber, coffee, macademia nuts and milk

Production / economic benefits

+++ Increased wood production (for timber and fuelwood)
++ Increased farm income
+ Increased fodder production (leaves used as fodder during dry season)
+ Increased crop yield (through mulching and nutrient pumping)

Ecological benefits

+++ Reduced wind velocity (affecting crops / homesteads)
++ Improved soil cover (mulch and canopy cover)
++ Improved micro-climate
++ Increased soil fertility and organic matter (leaf litter, leaves used as cattle bedding; nutrient recycling)
++ Reduced soil loss
+ Increased soil moisture (mulching improves infiltration)
+ Biodiversity enhancement (bees, birds, etc.)

Socio-cultural benefits

++ Improved conservation / erosion knowledge (stakeholder interaction)
++ Improved housing (more timber available)

Off-site benefits

+++ Reduced deforestation (alternative source of fuel and timber)
++ Creation of employment (tree management and harvesting)
+ Reduced downstream flooding and siltation
+ Reduced river pollution (chemical contamination)
+ Increased stream flow in dry season

Weaknesses ➜ and how to overcome

- Seedlings and wildings not always readily available ➜ encourage local seed collection and setting up of group tree nurseries.
- Timber is susceptible to pests attack (weevils) ➜ timber treatment with appropriate chemicals; breeding of pest tolerant varieties.
- Livestock can damage young seedlings ➜ protection by fencing.
- Dry periods result in low seedling survival rates: planting not possible in dry areas ➜ combine technology with water harvesting / moisture management techniques.
- Competition with crops ➜ regular pruning of side branches; dig a small trench around the trees, thus cutting the superficial roots.
- Limited efficiency of agroforestry system in combating soil erosion problems on slopes ➜ combine with agronomic and vegetative measures (e.g. contour ploughing, mulching, grass strips), and where necessary with structural measures (e.g. terraces, bunds and ditches).

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Case study

FARMER MANAGED NATURAL REGENERATION - NIGER

Farmer Managed Natural Regeneration (FMNR) is the systematic regeneration of living and sprouting stumps of indigenous vegetation which used to be slashed and burned in traditional field preparation. The naturally occurring seedlings and / or sprouts are managed and protected by local farmers. Most suitable are species with deep roots that do not compete with crops and have good growth performance even during poor rainy seasons. In the case study area the three most valuable species – as perceived by land users – are *Faidherbia albida*; *Piliostigma reticulatum* and *Guiera senegalensis*.
The ideal density, when grown with cereal crops, is between 50 and 100 trees per hectare. For each stump, the tallest and straightest stems are selected and side branches removed to roughly half of the stem height. Excess shoots are then removed. Regular pruning of any unwanted new stems and side branches stimulates growth rates. Farmers are encouraged to leave 5 stems / shoots per tree, cutting one stem each year and letting another grow in its place. On removing a shoot, the cut leaves are left on the surface where they reduce erosion and are then eaten by termites, returning the nutrients to the soil. The remaining shoots continue to grow, providing a continuous supply of wood. From the first year, firewood is collected from trimmings. From the second year on, cut branches are thick enough to sell. A more intensive form of FMNR is to profit from every stump sprouting on the land. This option allows idle land to become a productive resource during an otherwise unproductive eight-month dry season.
FMNR is a simple, low-cost and multi-benefit method of re-vegetation, accessible to all farmers, and adapted to the needs of smallholders. It reduces dependency on external inputs, is easy to practice and provides multiple benefits to people, livestock, crops and the environment. Tree layout will need to be carefully considered if ploughs are used for cultivation.

SLM measure	Vegetative and management
SLM group	Agroforestry
Land use type	Mainly annual cropping
Degradation addressed	Deforestation; Wind erosion and sedimentation (increased wind speed, dust storms); Water deficiency; Sand dune movements
Stage of intervention	Mainly rehabilitation, partly mitigation
Tolerance to climate change	Tolerant to climatic extremes (e.g. droughts, temperature increase, rainfall decrease, etc.)

Establishment activities

1. Select 50 - 100 stumps per hectare for regrowth during the dry season.
2. Select the tallest and straightest stems and prune side branches to roughly half the height of the stem (using sharpened axe or machete and cutting upwards carefully).
3. Remove excess shoots, leave the cut leaves on the surface.
4. Prune any unwanted new stems and side branches (each 2-6 months).

All activities carried out manually.

Maintenance / recurrent activities

1. Cut one stem (per tree) each year and let another grow in its place.
2. Once the stems selected for growth are > 2 meters high, they can be pruned up to two thirds.
3. Prune any unwanted new stems and side branches (each 2-6 months).

All activities carried out manually.
Note: Farmers in different countries have developed a range of management practices which best suit their needs and thus differ from the present case study.

Labour requirements

For establishment: low
For maintenance: low

Knowledge requirements

For advisors: medium
For land users: medium

Photo 1: Mature FMNR system in Maradi, with millet and a tree density of around 150 trees/ha.
Photo 2: New tree sprouts in front of the farmer, harvested wood in the background. Note the proximity of the crop (millet) to the tree without detrimental effect.
Photo 3: Re-sprouting tree stumps and roots: the basis of FMNR.
Photo 4: Typical FMNR farm after harvest of millet.
Photo 5: After just one year the numerous stems are growing vigorously and straight. Ideally, one or two are harvested from the clump each year, always leaving new regrowth to replace them. (All photos by Tony Rinaudo)

Case study area: Maradi, Niger

Establishment inputs and costs per ha

Inputs	Costs (US$)
Labour: 2-3 person-days	6
Equipment / tools: see below	0
Agricultural inputs: none	0
TOTAL	**6**
% of costs borne by land users	100%

Maintenance inputs and costs per ha per year

Inputs	Costs (US$)
Labour: 1-2 person-days	4
Equipment / tools: see below	0
Agricultural inputs: none	0
TOTAL	**4**
% of costs borne by land users	100%

Remarks: Main costs are in the form of labour. One man could prepare one hectare in 1–3 days, depending on tree density (labour is undertaken by the farm owner and rarely through paid labour). No inputs used; no extra tools needed, tools are available on-farm (hoe, axe, machete etc). Maintenance costs depend on tree density also and could require 1–2 days/year/ha.

Benefit-cost ratio

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

Remarks: Annual income from selling wood: US$ 140 (from the 6th year after implementation). By some estimates, total benefit per hectare (incl. wood sales, increased crop yield, increased livestock productivity, wild foods and medicines etc.) are in the order of US$ 200/ha, compared to an investment in labour US$ 10-15.

Ecological conditions

- Climate: semi-arid
- Average annual rainfall: 150–500 mm (variable)
- Soil parameters: low fertility, very low soil depth, drainage and organic matter content
- Slope: mainly flat, partly undulating
- Landform: mainly plains
- Altitude: 200–300 m a.s.l.

Socio-economic conditions

- Size of land per household: 1–5 ha (average production area)
- Type of land user: small-scale; very poor and poor land users
- Population density: 11 persons/km^2
- Land ownership: individual, generally untitled
- Land use rights: individual
- Level of mechanisation: mainly manual labour, partly animal traction
- Market orientation: mixed (subsistence and commercial)
- FMNR can be practiced by any farmer, even the poorest. No external

Production / economic benefits

+++ Increased wood production (production value increased by 57%)
+++ Increased income
+++ Increased crop production (at least doubled)
++ Reduced workload: no annual clearing / burning of trees
++ Increased livestock production (nutritious pods as fodder)

Ecological benefits

+++ Increased soil cover and increased biomass: increased tree density on farmland (from 30 to 45 trees/ha average)
+++ Windbreak effect: deposition of rich, wind blown silt; improved micro-climate
+++ Increased organic matter from leaf fall and trimmings
+++ Increased soil fertility (dung; livestock spends more time in fields with trees)
+++ Increased biodiversity; creation of habitat, food and shelter for predators of crop pests
+++ Increased drought-tolerance: regenerated trees are indigenous and generally have mature root systems

Socio-cultural benefits

++ Increased food security: edible leaves / fruits; bridge food shortages
+++ Improved quality of life: reduced wind speeds and dust; shade is available; barren landscape is returning to a natural savanna
+++ Increased disaster risk reduction: FMNR acts as an insurance policy

Off-site benefits

+++ Urban populations benefit from cheaper, sustained wood supply and reduced incidence of dust storms

Weaknesses ➜ and how to overcome

- Scarce presence of live tree stumps ➜ alternatively broadcast seeds of indigenous species (reduced short term benefits; high mortality rates).
- Cultural norms and values: 'a good farmer is a clean farmer' (= no trees) ➜ work with all stakeholders to change norms.
- Land (including trees) is treated as common property during dry season; damaging and removing trees on other people's land occurs ➜ create sense of ownership of trees: (1) encourage communities to develop rules that respect property; (2) local forestry authorities granting informal approval for farmers to be able to reap the benefits of their work.

Adoption

The technology has first been implemented in Maradi region, Niger in the early 1980's. Spread has been largely spontaneous, with minimal external assistance. The area covered today by trees from FMNR is estimated to be more than 50,000 km^2 in Niger.

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PARKLAND AGROFORESTRY SYSTEM - BURKINA FASO

Parklands are the traditional agroforestry systems of semi-arid West Africa or Sahel where naturally growing, valuable trees are protected and nurtured on cropping and grazing lands. For the rural people in the Sahel, parkland trees are multipurpose: they are a grocery shop, a pharmacy and a silo at the same time. People rely on many locally cherished species to provide food and nutritional security for both human and livestock populations and to protect and enrich soils. Important tree species are baobab (*Adansonia digitata*), tamarind (*Tamarindus indica*), *Faidherbia albida*, shea nut or *karité* (*Vitellaria paradoxa*, see photo 1 below) and *néré* (*Parkia biglobosa*).

Crop production can be increased below and around the trees (especially under *Faidherbida albida*) due to the favourable micro-climate, accumulation of soil organic matter through litter fall, prunings and root decay in the predominantly sandy and poor soils.

Parkland management practices include: assisted tree regeneration (see also Farmer Managed Natural Regeneration, Niger); Tree planting (mostly in vicinity of family compounds); Improved fallows (under which economically useful and fertility-improving trees are planted before cropping is discontinued) and fire protection. Farmers commonly apply silvicultural techniques to increase production of parkland trees. These include seedling protection and fencing, watering, and the selection of vigorous shoots. Pruning is done to improve productivity of trees, reduce shade and enhance understorey crop performance and to produce fuelwood and fodder. It stimulates leaf regrowth, causes an additional foliation peak during the rainy season and depresses pod production. Coppicing and pollarding represent a way of limiting competition with intercrops and providing wood and other tree products in species with good vegetative growth.

SLM measure	Vegetative
SLM group	Agroforestry
Land use type	Mixed (crops and trees)
Degradation addressed	Desertification problem; Fertility decline, reduced organic matter content; Loss of topsoil through water erosion
Stage of intervention	Mitigation
Tolerance to climate change	Increased tolerance through the use of indigenous species

Establishment activities

1. Retaining saplings from natural regeneration or wildings before rainy seasons.
2. Planting improved material (early stage).
3. Grafting for shortening juvenile phase and improving fruit quality (initiation stage).
4. Pruning to form erect canopy.
5. Protection from animals by dead or live fences.

Maintenance / recurrent activities

1. Weeding around seedlings when necessary (rainy season).
2. Pruning as necessary (pruned branches are dried and used for fuelwood): annually.
3. Pollarding (pruning of side branches to improve light for understorey crops.
4. Felling some trees to reduce density as they grow bigger (during dry season).

All activities carried out by manual labour using machetes (panga) or hoes.

Labour requirements

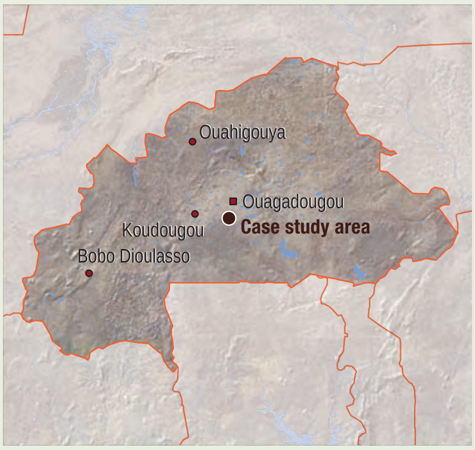
For establishment: moderate
For maintenance: high

Knowledge requirements

For advisors: moderate
For land users: low

Photo 1: *Karité* –millet parkland in Sapone, Burkina Faso. (Jules Bayala)
Photo 2: *Faidherbia albida* dominating a parkland system with pearl millet in Burkina Faso. (William Critchley)

Case study area: Saponé, Burkina Faso



Establishment inputs and costs per ha

Inputs	Costs (US$)
Labour	-
Equipment	-
Agricultural inputs	-
TOTAL	**no data**

Maintenance inputs and costs per ha per year

Inputs	Costs (US$)
Labour	-
Equipment	-
Agricultural inputs	-
TOTAL	**no data**

Remarks: Data on costs is not available. However, costs for management of the land use system are low; only some pruning and trimming of trees is needed which is effectively 'harvesting' of fodder and wood.

Benefit-cost ratio

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

Remarks: Costs of establishment and maintenance in traditional parklands are difficult to quantify because trees usually arise through natural regeneration and then are 'nurtured'. Annual returns from the sale of *neré* products were estimated at 50-60 US$ (26% of farmers' income) and *karité* / shea nut activities can represent 20–60% of women's income in rural areas.

Ecological conditions

- Climate: semi-arid
- Average annual rainfall: 720 mm (unimodal)
- Soil parameters: sandy loam, Regosols; low soil organic matter
- Slope: mostly flat
- Landform: plains
- Altitude: no data

Socio-economic conditions

- Size of land per household: 1-5 ha
- Type of land user: poor and better-off farmers (basically everyone who has land)
- Population density: 76 persons/km^2
- Land ownership: majority has ownership of the land, few borrow
- Land use rights: individual
- Level of mechanisation: manual labour
- Market orientation: mixed (subsistence and commercial)

Production / economic benefits

+++ Increased production from fruits
++ Increased farm income
+ Increased fodder production (leaves used as fodder during dry season)
+ Increased crop yield (through mulching and nutrient pumping)

Ecological benefits

+++ Reduced wind velocity (affecting crops / homesteads)
++ Improved soil cover (mulch and canopy cover)
++ Improved micro-climate
++ Increased soil fertility (leaf litter and nutrient recycling)
++ Reduced soil loss
+ Increased soil moisture (mulching improves infiltration)
+ Biodiversity enhancement (bees, birds, etc.)

Socio-cultural benefits

++ Improved conservation / erosion knowledge (stakeholder interaction)
++ Improved housing (more timber available)

Off-site benefits

+++ Reduced deforestation (alternative source of fuel and timber)
++ Creation of employment (tree management and harvesting)
+ Reduced downstream flooding
+ Reduced downstream siltation
+ Increased stream flow in dry season

Weaknesses ➜ and how to overcome

- Seedlings and wildings not always readily available ➜ encourage local seed collection and setting up of group tree nurseries.
- Livestock sometimes damage the young seedlings ➜ protection by fencing.
- Dry periods result in low seedling survival rates: planting not possible in dry areas ➜ combine technology with fencing.
- Competition with crops ➜ regular pruning of side branches.
- Long period to fruiting ➜ use vegetative propagation of superior trees.

Adoption

Tens of millions of people live in the traditional parklands of Burkina Faso, Mali, Senegal and Niger. In Mali alone an estimated 3.6 million people practice parkland agroforestry with 40 trees per hectare.

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