left: Bird's-eye view of the rectangular grid of shelterbelts established over wide expanses of cropland to reduce natural hazards and protect crops. (Liingqin Meng)
right: Detailed view of a shelterbelt established in the early 1960s. A road and an irrigation channel run between the tree rows. (Anonymous)

Shelterbelts for farmland in sandy areas

China – 沙区农田防护林

Belts of trees, planted in a rectangular grid pattern or in strips within, and on the periphery of, farmland to act as windbreaks.

Shelterbelts to protect cropland are a specific type of agroforestry system comprising certain tall growing tree species. Such shelterbelts around farmland help reduce natural hazards including sandstorms, wind erosion, shifting sand, droughts and frost. They also improve the microclimate (reduced temperature, wind speed, soil water loss and excessive wind-induced transpiration) and create more favourable conditions for crop production. Thus the establishment of shelterbelts plays a crucial role in the sandy drylands that are affected by wind and resultant desertification especially during winter and spring. Where there is irrigation, the shelterbelts protect the infrastructure from silting-up with wind-borne sediment.

Strips of tall growing species (15–25 m) of poplar *(Populus spp.)* or willow *(Salix spp.)* were originally (from 1960s onwards) planted in a 400 by 600 m rectangular grid pattern within extensive areas of cropland, with an extra belt of windbreaks on the windward side (against the prevailing wind). Generally, the distance effectively protected is 15–25 times the tree height. Strips are of variable width, consisting of 2–5 tree lines (1–3 m apart) with trees planted every 1–2 m within the lines. Selective felling is used to maintain adequate growing space and the protective effect of the trees.

The impact of the shelterbelts depends on the planting pattern of the trees (the format of strips and grids), the orientation of the shelterbelts in relation to the wind, the spacing between, and the width of each strip and the type of trees planted. The specific design is primarily based on preventing the negative effects of wind, but depends also on local conditions such as the layout of the land, the location of the roads, farm boundaries and irrigation canals. Ideally the tree strips are perpendicular to the prevailing wind direction, and the angle between the strip and the prevailing wind is never less than 45 degrees. The structure of the strips determines the way the wind is controlled, ranging from blocking the wind to letting it diffuse through semi-permeable shelterbelts. The best effect is achieved if the wind is not blocked entirely, as this can cause turbulence.

The ownership of the land and the shelterbelts still rests with the state, but management has been more and more transferred to individual households. On condition that the impact of the shelterbelt is not affected, the local forestry agencies now allow some felling of mature trees – on a rotational and selective basis, for timber and firewood. Pine trees *(Pinus sylvestris var. mongolica* and *P. tabulaeformis),* which command high value as timber for construction, and fruit (and cash) trees like the apricot tree *(Prunus armeniace)* are increasingly used.

Location: Inner Mongolia Autonomous Region, People's Republic of China
Technology area: 500 km^2
SWC measure: vegetative
Land use: cropland (before), mixed: agroforestry (after)
Climate: semi-arid
WOCAT database reference: QT CHN48
Related approach: not documented
Compiled by: Hai Chunxing, Wang Dongmei, Wang Yaolin, PR China
Date: May 2002, updated October 2006

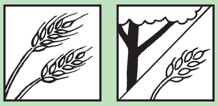
Editors' comments: In China, a total of 1.84 million km^2 suffer from desertification related to sand storms, shifting sands and wind erosion, making up 19% of the total land area. In those dry and desertified zones, farmland is barely productive, even with irrigation. The construction of shelterbelts in this northeastern part of China has had multiple benefits that outweigh the loss of cropland. However, maintenance has become an important issue with the changes in China's land use laws. This is one of two examples of windbreaks amongst the case studies in this book.

Classification

Land use problems

Strong winds in the winter and spring result in serious natural hazards including sand storms, sand encroachment and wind erosion, while dry and hot winds in the summer increase transpiration leading to plant stress and reduced crop yields.

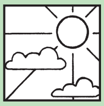
Land use



annual crops: maize/wheat, suppl. irrig. (before)

agroforestry, suppl. irrig. (after)

Climate



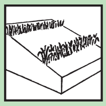
semi-arid

Degradation

wind erosion: loss of topsoil, deflation/deposition

water: reduced soil moisture

SWC measures



vegetative: aligned trees (windbreaks)

Technical function/impact

main:
- reduction in wind speed
- protection from wind erosion
- protection from sand encroachment
- protection of crops from mechanical damage
- reduction in evaporation loss
- soil moisture conservation

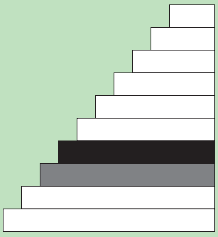
secondary:
- mitigation of sand storms
- preventing siltation of irrigation canals
- maintenance of organic matter

Environment

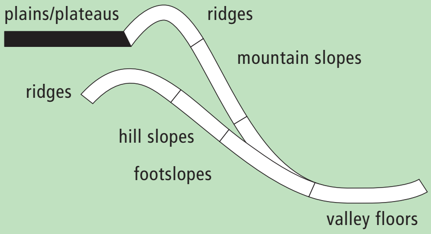
Natural environment

Average annual rainfall (mm)

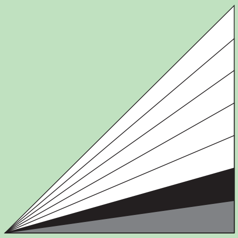
Altitude (m a.s.l.)



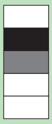
Landform



Slope (%)



Soil depth (cm)



NB: soil properties before SWC

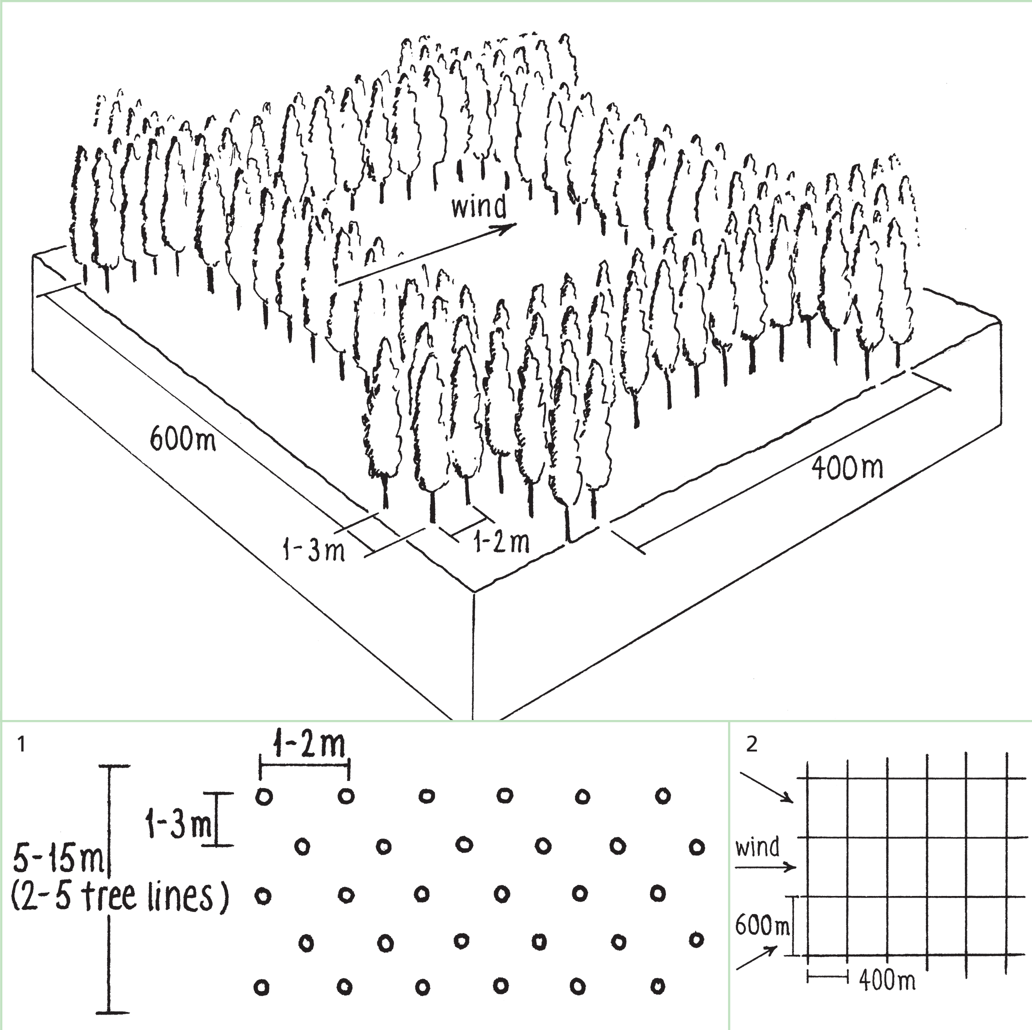
Growing season: around 150 days (May to September)
Soil fertility: medium to low
Soil texture: coarse (sandy)
Surface stoniness: no
Topsoil organic matter: medium (1–3%)
Soil drainage: good
Soil erodibility: medium

Human environment

Mixed land per household (ha)

Land use rights: individual (for cropland – though not usually the land directly under shelterbelts)
Land ownership: communal/state
Market orientation: mixed (subsistence/commercial)
Level of technical knowledge required: field staff/extension worker: moderate, land user: low
Importance of off-farm income: 10–50% of all income: farmers benefit from the shelterbelts as a source of off-farm income, through fodder, timber and firewood

Remark: In the 1960s, all land ownership and land use rights in China were communal and cropland was farmed collectively by village communes. After reform and open policy was put into practice in 1978, land use rights were transferred to the villages, to groups and individuals. Land itself and the shelterbelts however still belonged to the state. Nowadays the rights to cultivate specific parcels of land, within protected blocks, are generally granted to individual farm households. In some cases, in recent years, the shelterbelts too have been redistributed to individuals to look after. Inevitably maintenance has become an issue. But most of the shelterbelts are managed well.



Technical drawing
Overview of the shelterbelt layout.
Insert 1: Planting scheme: shelterbelts comprise 2–5 tree lines forming the windbreak about 5–15 m wide and 15–25 m high.
Insert 2: Rectangle grid layout of shelterbelts. Spacing of the rows is denser against the prevailing wind.

Implementation activities, inputs and costs

Establishment activities
1 Planning/designing of shelterbelt.
2 Selection and collection of trees seedlings.
3 Clearing and preparing land for planting of shelterbelt in late spring and autumn.
4 Pits for planting the seedlings are dug by hand using shovels and pickaxes in late autumn and spring.
5 Tree seedlings are planted in late spring.
6 After planting each seedling is watered by hand for up to two years.

Duration of establishment: 2–3 years

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour (25 person days)	95	0%
Equipment		
- Tools (shovel, pickaxe, bowser)	5	100%
Agricultural		
- Tree seedlings (104)	25	0%
TOTAL	**125**	**4%**

Maintenance/recurrent activities
Pruning of trees.
Pest and disease control within shelterbelt.
Intermediate/ selective tree felling.
Once established the shelterbelt requires minimal maintenance.
Replanting is carried out after felling of single lines of mature trees.

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Labour (2 person days)	8	100%
Agricultural		
- Seedlings (10)	3	100%
TOTAL	**11**	**100%**

Remarks: The costs are calculated according to current standards/costs. The original planting is paid for by the state: re-planting and maintenance are the responsibility of the land user. If pines are the species of choice for re-planting, the cost is considerably more than that shown above (which relates to poplar and willow).
Assuming: shelterbelts of 600 m by 400 m; each strip has 5 lines of trees (3 m apart), 2 m between trees within lines: resulting in 104 trees/ha, including the cropland between the strips (density within strips is 1666 trees/ha).
Labour for establishment (104 trees): Land preparation, planting 10 days and 15 days for watering, weeding, etc (for first 3 years).

Assessment

Acceptance/adoption

Shelterbelts and irrigation canals were established through a government project in which the large majority of the costs were met by the state. The technology has not spontaneously spread beyond the areas developed through government intervention.

Benefits/costs according to land user

Benefits compared with costs	short-term:	long-term:
establishment	not specified	not specified
maintenance/recurrent	slightly positive*	very positive*

* If farmer cuts mature timber (for example a 40 year-old poplar), he/she can sell it for US$ 20–25 per tree. With maturity of shelterbelts, the timber production increases, which brings increasing economic benefits; meanwhile, the effect of protection from wind erosion also improves.

Impacts of the technology

Production and socio-economic benefits

- +++ wood production increase
- ++ crop yield increase
- ++ farm income increase
- ++ off-farm income increase (extra timber and firewood)

Production and socio-economic disadvantages

- −− loss of land (width of the shelterbelt)
- −− competition with crops for solar radiation, fertilizer, and water

Socio-cultural benefits

- + improved knowledge SWC/erosion

Socio-cultural disadvantages

- −− shelterbelts of trees are not a direct source of food – this leads to a negative attitude amongst some farmers

Ecological benefits

- +++ soil cover improvement
- +++ increase in soil moisture
- +++ soil loss reduction
- +++ reduction of wind velocity
- +++ reduction of sand encroachment
- +++ improving microclimate for crops: regulating temperature, increasing humidity
- ++ conservation/maintenance of soil fertility

Ecological disadvantages

- − water consumption by trees

Off-site benefits

- +++ reduced effects of sand storms (encroachment)
- +++ improved microclimate around protected cropland areas

Off-site disadvantages

none

Concluding statements

Strengths and ➜ how to sustain/improve

Reduced wind speed and trapped wind-blown sand particle ➜ Combine deciduous and evergreen trees to maintain shelterbelt's protective function throughout the year.

Increased crop yield ➜ Extend shelterbelt technology to unprotected croplands.

Increased cash income ➜ Improve rotational felling regimes that maximise quantity and quality of tree products (timber; fruit etc) without reducing the shelterbelt's protective function. In Inner Mongolia apricot *(Prunus armeniaca)* and sea buckthorn *(Hippophae rhamnoides)* and in Gansu Province the Chinese dates *(Ziziphus jujuba)* are incresingly used.

Apart from their effect on the wind, the overall benefits of the shelterbelts – for timber, firewood, fruits and fodder for animals – outweigh the loss of cropland occupied by the trees ➜ Experience over 40 years has demonstrated that narrower trees strips and smaller grid size (100 by 200 m) would increase ecological efficiency, but due to higher costs and potential competition with crops, the spacing of the shelterbelts has mostly remained as it was originally.

From 1960 onwards, approximately 22 million hectares – of vulnerable cropland have been protected in eastern Inner Mongolia.

Weaknesses and ➜ how to overcome

Loss of land due to area used for the shelterbelts ➜ In this wind-prone part of Inner Mongolia, overall gains from the protected zones compensate for the reduced area under crops, especially if economically valuable species are planted in the shelterbelt, such as Caragana korshinskii, which can be used as forage, for 'green fertilizer' through leaf mulch and for firewood.

Competition for sunshine, fertilizer and water ➜ Pruning of branches and digging of ditches to prevent roots penetrating the adjacent cropland

Farmers lost the right to crop the tree-occupied land (since the shelterbelts belonged to the state). Originally, farmers were not allowed to fell trees ➜ Nowadays the local forestry department permits farmers to occasionally cut trees, which is a source of income. If land users were allowed to cut trees on a more systematic basis, it would help them to better appreciate the benefits.

High cost (labour and money) for establishment ➜ Government support required.

Shelterbelts comprised of single tree species are less resistant to pests and diseases ➜ Combine trees and shrubs/ different species, which improves both resistance and also the protective effect.

Shelterbelts consume more water ➜ But they also help in drainage (where this is a problem) through lowering the ground water table and simultaneously reducing salinity. Appropriate tree species need to be selected and bred.

Key reference(s): Compilation Committee of Inner Mongolia Forest (1989) *Inner Mongolia Forest,* Beijing: China Forestry Publishing House, 1989, 299–319

Contact person(s): Hai Chunxing, College of Geographical Sciences, Inner Mongolia Normal University, No. 295 Zhaowuda Road, Hohhot, Inner Mongolia 010022, People's Republic of China ▪ Wang Yaolin, Gansu GEF/OP12 Project Office, Lanzhou, PR China


left: Boundary planting in drier areas of the Mount Kenya region: grevillea provides a variety of ecological and economic benefits and is adapted to different agro-ecological zones. (Hanspeter Liniger)
right: Scattered grevillea trees associated with annual crops protecting slopes by a stream. (Hanspeter Liniger)
For a picture of grevillea lines on terrace risers ('alley cropping'), see page 20.

Grevillea agroforestry system

Kenya – *Mukima / Mubariti*

Multipurpose *Grevillea robusta* trees planted along farm boundaries, on terrace risers and occasionally scattered in cropland.

While *Grevillea robusta* (the 'silky oak', an Australian native tree) was originally introduced from India to East Africa as a shade tree for tea and coffee estates, it is now more commonly associated with small-scale farming areas. There are three main forms of grevillea agroforestry systems: (1) most commonly trees are planted along farm boundaries, initially at a close spacing (0.75–1 m), then later thinned to 1.5–3 m, giving approximately 400 plants/ha; (2) scattered grevillea trees associated with annual or perennial crops: resembling open forests with multi-storey layers; (3) grevillea is sometimes grown in a form of 'alley cropping' on terraces, with 4–8 m interval between the rows and a spacing of 3–5 m within the rows.

Grevillea is primarily used in combination with annual (maize/beans) and perennial crops (coffee). It can be easily propagated and established and is relatively free of pests and diseases. Trees are managed through periodic pollarding – the pruning of side branches (for use) while maintaining the trunk. This gives the visual impression of 'telegraph poles', but competition with crops (which is little, in any case) is reduced and pruned branches rapidly regrow. An additional measure for avoiding competition with crops is to dig a small trench around the trees, thus cutting the superficial roots.

Grevillea is planted for a number of purposes. These include marking property boundaries, supplying fuelwood and building materials, providing shade and for ornamental value. Simultaneously it can control raindrop splash (when an understorey of litter builds up beneath), increases organic matter, and provides mulching materials to improve ground cover in the farm. Grevillea reduces wind speed, and encourages nutrient recycling due to its deep rooting.

While the climate in the case study area is subhumid, and the slopes moderate to steep with soils of medium erodibility, grevillea can be planted over a wide range of agroecological zones – from semi-arid to humid zones, and from sea level up to 2,000 metres and higher. It is ideally suited to intensive areas of small-scale mixed farming, where grevillea is valued primarily for the supply of products (fuel and construction wood in particular) to meet various household needs: it is not mainly targeted at soil erosion control though this is achieved in various ways as explained above. 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 forms of conservation.

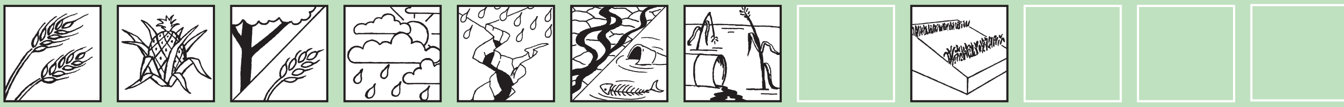
Location: Kiawanja catchment, Nembure division, Embu, Kenya
Technology area: 1.5 km^2
SWC measure: vegetative
Land use: cropland (before), mixed: agroforestry (after)
Climate: subhumid
WOCAT database reference: QT KEN16
Related approach: Spontaneous spread, QA KEN08
Compiled by: John Munene Mwaniki, Embu, Kenya/updated by Ceris Jones, Agronomica, UK
Date: September 2002, updated June 2004

Editors' comments: *Grevillea robusta* originates from Australia. It was used in India for shade, and as a windbreak, in tea and coffee estates. Then, during the early 20th century, it was introduced to East Africa for the same purpose. It has gained increasing popularity amongst local farmers since the 1970s, and is now the most common multipurpose agroforestry tree in small-scale farms in the region.

Classification

Land use problems
- land degradation, mainly by water erosion
- soil fertility decline due to continuous cropping and few inputs
- lack of fuelwood, building materials, and other tree related products

Land use | **Climate** | **Degradation** | **SWC measures**



annual crops: maize/beans (before) | perennial crops: coffee, macadamia (before) | agroforestry: grevillea trees, maize/beans, coffee (after) | subhumid | water erosion: loss of topsoil | water degradation: soil moisture problem | chemical: fertility decline, reduced organic matter content | vegetative: tree rows, scattered trees, 'alley cropping'

Technical function/impact

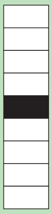
main:
- improvement of ground cover (mainly leaf mulch from pruning)
- reduction in wind speed
- increase in organic matter
- plant nutrient recycling due to deep rooting

secondary:
- control of raindrop splash
- increase of infiltration
- improvement of soil structure

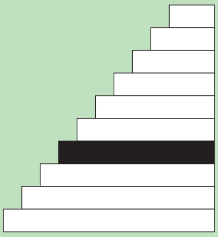
Environment

Natural environment

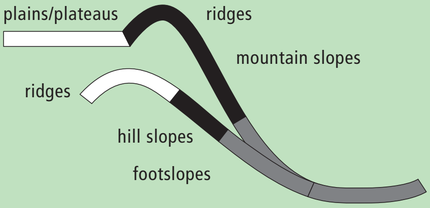
Average annual rainfall (mm)



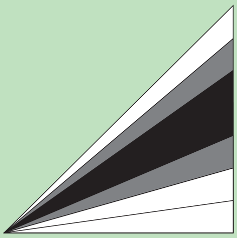
Altitude (m a.s.l.)



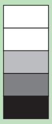
Landform



Slope (%)



Soil depth (cm)



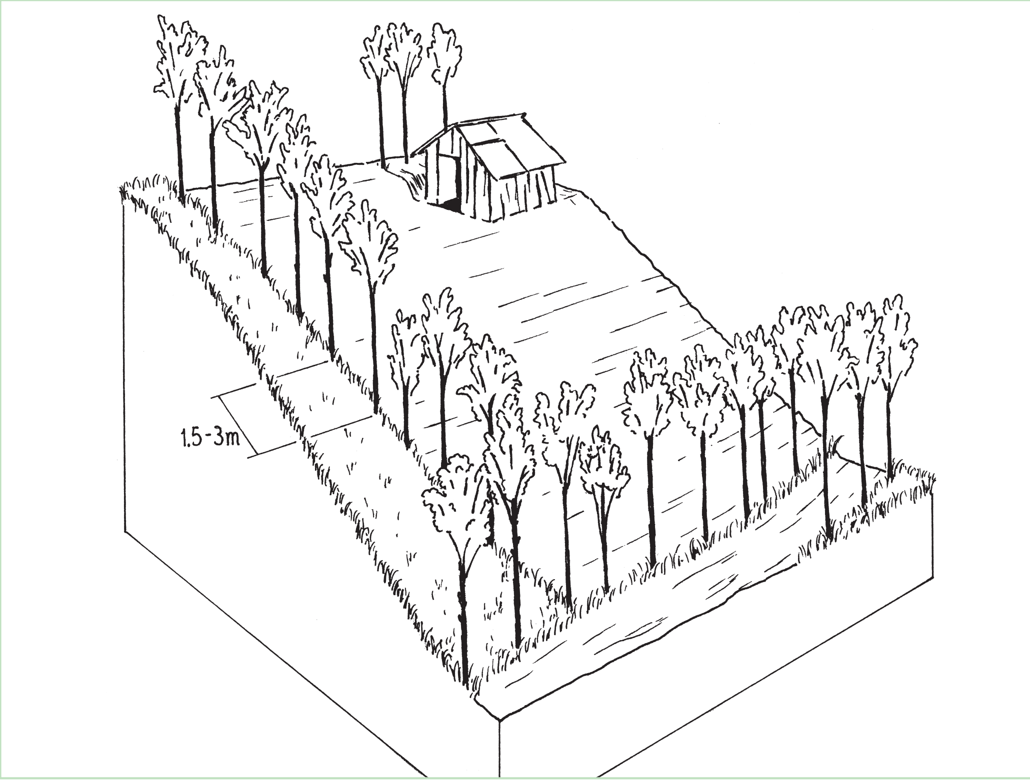
NB: soil properties before SWC

Growing season: 120 days (March to June) and 120 days (October to January)
Soil fertility: mostly medium; partly low; rarely very low
Soil texture: mostly medium (loam), some fine (clay)
Surface stoniness: mostly no loose stone, partly some loose stone
Topsoil organic matter: mostly low (<1%), partly medium (1–3%): crop residues are rarely left to allow fertility to build-up; some manure added but generally insufficient
Soil drainage: good drainage: sloping and deep well drained nitosols
Soil erodibility: mostly medium

Human environment

Mixed land per household (ha)

Land use rights: individual
Land ownership: individual titled
Market orientation: mixed (subsistence and commercial): coffee, macadamia nuts, grevillea timber, and milk form dairy cows are the main marketed products
Level of technical knowledge required: field staff/extension worker: moderate, land user: low
Importance of off-farm income: <10% of all income: few land users have off-farm employment



Technical drawing
Grevillea tree are most commonly planted along field or farm boundary – but also around houses. Spacing of trees is initially dense; later they are thinned. Other options (not shown here) are scattered planting in association with annual/ perennial crops, or in rows along terraces.

Implementation activities, inputs and costs

Establishment activities

1. Dig planting pits (before rainy seasons).
2. Purchase seedlings from nurseries/collection of wildings (naturally regenerated seedlings) at onset of rains.
3. Transplant (at onset of rains).

All activities carried out by manual labour using *pangas* (machetes) and hand hoes.
Duration of establishment: 1–2 years

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour (20 person days)	25	100%
Equipment		
- Tools	10	100%
Agricultural		
- Seedlings of grevillea (1,000)	125	100%
TOTAL	**160**	**100%**

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 reduced competition with annual crops every four years.
5. Felling some trees to reduce density as they grow bigger (during dry season).
6. Replanting if/when trees are harvested for timber.

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

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Labour (50 person days)	65	100%
Equipment		
- Tools	25	100%
TOTAL	**90**	**100%**

Remarks: Basis of costing: boundary planting (assuming average plot size of 25 m x 25 m (0.16 ha) 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) as well as establishment of personal or group nurseries.

Assessment

Acceptance/adoption

- 100% of land users (all 120 families in the area) accepted the technology without incentives. Adoption was spontaneous. Men and women are both involved with grevillea: men focus on timber for construction and sale, while women are more concerned with fuelwood.
- There is no longer a trend towards ‘growing spontaneous adoption’ because all land users in the catchment plant grevillea.

Benefits/costs according to land user	Benefits compared with costs	short-term:	long-term:
	establishment	slightly positive	very positive
	maintenance/recurrent	slightly positive	very positive

Impacts of the technology

Production and socio-economic benefits

- +++ wood production increase (for timber and fuelwood)
- ++ farm income increase
- + fodder production (leaves provide limited fodder during dry periods)
- + crop yield increase (through mulching and nutrient pumping)

Production and socio-economic disadvantages

- −− increased labour constraints (labour for tree establishment and maintenance can conflict with other activities)
- − reduced production (only where tree management is poor)
- − loss of land (occupies part of cropland) – but compensated by tree products

Socio-cultural benefits

- ++ improved knowledge on SWC/erosion (interaction with other stakeholders)

Socio-cultural disadvantages

- − boundary conflicts (potential for shading neighbours' crops)

Ecological benefits

- +++ reduction of wind velocity (windbreaks for crops and homesteads)
- ++ soil cover improvement (mulch and canopy cover)
- ++ microclimate improvement
- ++ increase in soil fertility (leaf litter and nutrient recycling)
- ++ soil loss reduction
- + increase in soil moisture (encouraging infiltration through mulching)
- + biodiversity enhancement (bees, birds, etc)

Ecological disadvantages

none

Other benefits

- ++ improved housing (more timber available)
- + ornamental value

Other disadvantages

- −− growing reliance on single exotic, replacing other local tree species; potential problem of reduced biodiversity

Off-site benefits

- +++ reduced deforestation (alternative source of fuel and timber)
- ++ creation of employment (through tree management and harvesting)
- + reduced downstream siltation (reduced soil erosion)
- + reduced river pollution (reduced sediment load in the streams)
- + reduced downstream flooding (infiltration encouraged)
- + increased stream flow in dry season

Off-site disadvantages

none

Concluding statements

Strengths and ➜ how to sustain/improve

Multipurpose tree, meeting various socio-economic needs: provision of fuelwood (for household energy needs) and timber, boundary marking, ornamental function; leaves provide fodder during severe drought ➜ Self-sustaining (no action needed).

Ease of propagation with minimal technical skill ➜ Self-sustaining (no action needed).

Income generation opportunities (eg selling tree products) ➜ Improvement in rural access roads to facilitate transport of tree products and other farm produce to market; encourage diversification: eg furniture making.

Microclimate improvement.

Crop yields are boosted by the tree nutrient recycling, fallen leaves add organic matter on decomposition.

Reduction of runoff and hence soil erosion can be significant. The tree canopy associated with an understorey of litter reduces raindrop impact while the roots hold soil in place.

Weaknesses and ➜ how to overcome

Seedlings and wildings not always readily available ➜ Encourage local seed collection and setting up of group tree nurseries.

Timber susceptibility to pests attack ➜ Timber treatment with appropriate chemicals; breeding of more pest tolerant varieties – particularly against weevils.

Livestock sometimes damage the young seedlings ➜ Protection by fencing.

Dry periods result in low seedling survival rates: planting not possible in dry areas ➜ With water harvesting and moisture management techniques, the technology could spread to lower rainfall areas.

Key reference(s): ICRAF (1992) *A selection of useful trees and shrubs in Kenya.* ICRAF, Nairobi ■ Guto et al (1998) *PRA report, Kiawanja catchment, Nembure division, Embu District-Kenya.* Ministry of Agriculture, Nembure division, Embu ■ Harwood CE (1989) *Grevillea robusta: an annotated bibliography:* ICRAF, Nairobi ■ Rocheleau D, Weber F and Field-Juma A (1988): *Agroforestry in dryland Africa:* ICRAF, Nairobi http://www.winrock.org/forestry/factpub/factsh/grevillea.htm ■ http://www.ces.uga.edu/pubcd/b949-w.html
Contact person(s): John Munene Mwaniki, Ministry of Agriculture & Rural Development, Box 4, Embu, Kenya; phone ++254-722383771; mwanikijm2002@yahoo.com ■ Ceris Jones, Agronomica, UK; ceris.a.jones@btopenworld.com


left: Discussing the relative merits of grevillea planting among farmers and extension agents. (Ceris Jones)
right: Detailed view of a dense grevillea tree row planted along a farm boundary. (Ceris Jones)

Spontaneous spread

Kenya

Spontaneous land users' initiative to meet household needs – especially firewood and timber – through planting *Grevillea robusta* trees as part of an agroforestry system.

Grevillea robusta is a well-known shade tree, used in coffee and tea plantations in East Africa since the early part of the 20th century. While it originates from Australia, it was brought over from India and Sri Lanka by European settlers. Smallholder farmers in the highlands of Kenya noted that there was little or no competition between grevillea and neighbouring crops. Indeed this is one of the reasons it was so successful as a shade tree amongst plantation crops. Responding to the local lack of timber and firewood, due to the expansion of farmland into previously forested areas, smallholders took to planting grevillea, especially as a boundary tree, from the 1970s onwards. While the immediate effect of grevillea planting was to satisfy those needs for wood, the tree also helps in various ways to conserve land and improve the soil. This too was probably a reason for its spontaneous spread.

Because planting of grevillea requires few resources other than tools, even poor land users can readily adopt the technology. Although seedlings can be bought from local Government, NGO or private nurseries, it is also possible to collect ‘wildings’ (naturally generated seedlings) and plant these at minimal cost. The management of grevillea trees, once established, is important to their performance in the field, but the skills of thinning, and pollarding (pruning side branches for use) can be easily learned from neighbours. The success of the spontaneous spread of grevillea, basically through farmer-to-farmer exchange of knowledge, demonstrates that tree planting is not something that has always to be ‘pushed’ by outside agencies. Where smallholders perceive a need for trees and tree products – and an appropriate species is available – they will respond positively. However there is still an important ‘pulling’ role to be played by the Ministry of Agriculture’s extension agents and NGOs, especially through support for tree nurseries and for training to establish private tree nurseries.

Location: Kiawanja catchment, Nembure district, Embu, Kenya
Approach area: 1.5 km^2
Land use: cropland (before), mixed: agroforestry (after)
Climate: subhumid
WOCAT database reference: QA KEN08
Related technology: Grevillea agroforestry system, QT KEN16
Compiled by: John Munene Mwaniki, MoA, Embu, Kenya; update by Ceris Jones, Agronomica, UK
Date: May 1999, updated June 2004

Editors’ comments: There are few recent examples of the spontaneous spread of sustainable land management practices that have occurred without any significant outside push. The planting by smallholders of *Grevillea robusta* in East Africa, as part of an agroforestry system, is one. In the case study area almost all farmers now plant the multipurpose grevillea tree.

Problem, objectives and constraints

Problem
- shortage of fuelwood and building materials, environmental degradation
- need for farm boundary marking
- lack of simple, widely applicable agroforestry recommendations

Objectives
- improve availability of tree products (fuelwood and wood for construction)
- demarcate own land easily and cheaply (after land registration)
- reduce land degradation
- increase land productivity
- improve household income

Constraints addressed

Major	Specification	Treatment
Technical/financial	Shortage of tree seedlings and sourced from long distance.	Setting up of individual on-farm tree nurseries and collection of wildlings.
Social/cultural/religious	Boundary planting disagreements.	Agreement between neighbours on planting trees 6 m from their mutual boundaries.
Minor	**Specification**	**Treatment**
Social/cultural/religious	Gender bias – women not expected to plant trees.	Although not directly related to this approach, various campaigns were conducted by government and NGOs to encourage gender balance with respect to tree planting.

Participation and decision making

Target groups

Land users

Approach costs met by:

National government	10%
Individual land user	90%
	100%

Decisions on choice of the technology: Made by land users alone (land user-driven initiative by shortages/problems).
Decisions on method of implementing the technology: Made by land users alone (the land user decided on when and how to plant the trees).
Approach designed by: Land users.

Community involvement

Initiation	self-mobilisation	innovative individuals planting grevillea
Planning	self-mobilisation	informal, individual plans
Implementation	self-mobilisation	some support by government
Monitoring/evaluation	passive	ad hoc observations by MoA
Research	none	no activities

Difference in participation between men and women: It was traditionally the role of adult men to purchase, collect and plant trees. This is however changing: other groups – women and youth – are now planting trees as well.

Farmers and extension agents monitoring grevillea tree rows in the field (left). The advantages of the trees are manifold: economically, the most important benefits are production of timber (centre) and firewood (usually through pruning of side branches – 'pollarding' – right). (Hanspeter Linger)

Extension and promotion

Training: Some demonstrations of benefits of tree planting by Government at provincial agricultural shows.
Extension: Informal farmer-to-farmer exchange of ideas and skills. Additionally, on national tree planting days, the government has provided some free seedlings. Grevillea planting has been encouraged during national campaigns (involving the Ministry of Agriculture, the Ministry of Environment and Natural Resources, and NGOs) to encourage soil and water conservation. There is also some collaboration between the Government extension service and KARI (Kenya Agricultural Research Institute) to further promote the technology.
Research: Research has not been part of this approach.
Importance of land use rights: Private land ownership has given farmers confidence to invest the land, and has also been a direct stimulus through the need to mark plot boundaries.

Incentives

Labour: All labour has been provided voluntarily by individual land users.
Inputs: No inputs – apart from some seedlings on national tree planting days – provided.
Credit: No credit has been provided, nor has it been necessary.
Support to local institutions: No support provided.
Long-term impact of incentives: No incentives provided.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Technical	ad hoc observations of management methods by Ministry of Agriculture (MoA) extension staff
Economic/production	ad hoc observations of better housing, and fuelwood supply by MoA extension staff
Area treated	ad hoc observations of tree density by MoA extension staff

Impacts of the approach

Changes as result of monitoring and evaluation: There were no changes.
Improved soil and water management: Moderate improvements through planting of grevillea trees: better soil and water management, increase in soil organic matter levels, nutrient pumping and reduced soil erosion.
Adoption of the approach by other projects/land users: Some other extension programmes are utilising individual initiatives as an entry point.
Sustainability: As land users developed this approach they can continue activities without support.

Concluding statements

Strengths and ➜ how to sustain/improve
Self-driven initiative ➜ MoA extension staff and land users to encourage other farmers to be self-reliant.
Very low inputs (resources) required. However there is still an important 'pulling' role to be played by the Ministry of Agriculture's extension agents and NGOs ➜ More support for individual and government tree nurseries.
Incentives not necessary.
Adaptability, flexibility and simplicity since it is user driven.
Strong land user 'ownership' of the approach.
Valuable lessons from a farmer-driven success for development agencies that promote tree planting and agroforestry systems.

Weaknesses and ➜ how to overcome
Adoption rates under such approaches depend on the number and efforts of innovators to stimulate others ➜ SWC extensionists (Ministry and NGOs) to undertake more community mobilisation and awareness raising.
Approach is dependent on social cohesiveness for dissemination ➜ Promote more farmer interaction at community level.
Poor collaboration and institutional linkages ➜ Encourage and create forums where stakeholders can share experiences and inform land users about where to seek additional information and assistance.

Key reference(s): Njiru NN et al (1998) *Participatory Rural Appraisal report of Kiawanja catchment.* Nembure District, Eastern Province ■
See 'Grevillea agroforestry system' case study for technical references
Contact person(s): JM Mwaniki, Ministry of Agriculture/Soil and Water Conservation Branch, Embu, Kenya; mwanikijm2002@yahoo.com ■
Ceris Jones, Agronomica, UK; ceris.a.jones@btopenworld.com

left: Lines of hybrid poplar trees, 15 years old. Soil around the poplars is much drier: at a distance of around 20 m the soil is moist and covered by reeds. (Hanspeter Liniger)
right: Training in the field: a researcher explains the impact of the poplar system on the groundwater level to a group of students. (Hanspeter Liniger)

Poplar trees for bio-drainage

Kyrgyzstan – Выращивание тополя на заболоченных и сильно засоленных почвах

Poplars planted to lower the ground water table and reduce salinity where irrigation drainage systems have broken down; lucerne cultivated between the tree lines.

In irrigated areas of Central Asia, the drainage system introduced during soviet times has broken down due to lack of maintenance. As a result, water tables have been rising and soil salinity increasing. In the Chui Valley, which is the main crop production area in Kyrgyzstan, approximately 90% of the cultivated land is irrigated for wheat, maize, sugar beet, lucerne and vegetables. Of this, approximately one third (ca. 320,000 ha) is degraded due to loss of fertility, salinisation and waterlogging.

The individual initiative described here – poplar planting – has been applied on a degraded plain (about 400 m a.s.l.), under semi-arid conditions on a plot of 5 hectares. Though initially planted for timber, an important side effect was noted by the farmer in question. Poplar trees, well known for their tolerance to waterlogging and salinity, provide 'bio-drainage'. Excess water is rapidly taken up by the root system and transpired through the dense foliage. Within the plantation the humidity level of the lower layers of air is increased, thus reducing the influence of the dry, hot winds. A more favourable microclimate for plant growth is thus created. Simultaneously the original purpose of planting – to obtain cheap timber and firewood – is achieved through the rapid growth of the trees: there is a severe shortage of wood locally.

The varieties used include the local *Populus alba* and *Populus nigra* as well as a hybrid from Kazakhstan, *P. pyramidalis.* The trees are planted in rows about 5 metres wide, separated by 10–15 metre strips planted with *Medicago sativa* (lucerne) and *Bromus inermis* (a grass), both of which are grown for hay (see technical drawing). Around 3,000 saplings are needed per hectare. The young poplars require irrigating during the first year before their roots can reach the water table. The trees are weeded and their lower branches pruned to encourage straight and fast growth. They are thinned twice before they are 14 years old: these thinnings can be sold. The poplars then remain until they are 20–25 years old and suitable for felling. The output of commercial timber of a poplar plantation is 3,000 m^2 per hectare (1 m^2 per mature tree). Slow-growing/sick trees, as well as pruned branches, are used as firewood - which can amount to 20–30 m^3 per hectare. The cycle begins again after approximately 10 years, when new saplings are planted between the existing, thinned, lines of poplars. Desalinisation of the soil takes 10 years or a little longer, when it again becomes suitable for irrigated cereal cropping.

Location: Besh-Terek, Chui valley, Kyrgyzstan
Technology area: 0.05 km^2
SWC measure: vegetative and agronomic
Land use: wasteland (before), mixed: agroforestry (after)
Climate: semi-arid (harsh continental)
WOCAT database reference: QT KYR01
Related approach: not documented
Compiled by: Budaychiev Dayr, Asanaliev Abdybek, Sydykbaev Talant, Bishkek, Kyrgyzstan
Date: January 2004, updated May 2004

Editors' comments: Some trees are known to drain ground water and lower water tables. Eucalyptus is perhaps the best-known example. This case study shows how one farmer in Kyrgyzstan originally planted poplar trees for wood. The effect of lowering the water table and reducing salinity was only realised later on. It shows great potential where groundwater tables have risen due to failures in maintaining conventional drainage systems.

Classification

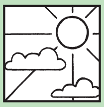
Land use problems

Irrigation drainage systems have deteriorated (silted up, choked with weeds and reeds) due to lack of maintenance. This has led to a raised water table, waterlogging and increased salinity, thus seriously affecting productivity and making cultivation of some crops impossible. Farmers' incomes have significantly reduced as a result.

Land use

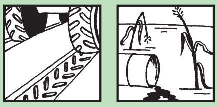
annual crops: irrigated (before degradation) | wasteland (before SWC) | agroforestry: poplar, lucerne, wheat (after)

Climate



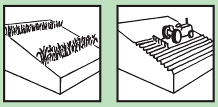
semi-arid

Degradation



physical: waterlogging | chemical: salinisation, fertility decline

SWC measures



vegetative: trees aligned (windbreaks) | agronomic: legume inter-planting (lucerne)

Technical function/impact

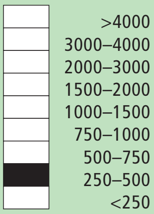
main:
- lower ground water level
- decrease waterlogging
- reduce risk of salinisation
- improve soil fertility

secondary:
- reduction in wind speed
- increased air humidity
- cooling effect

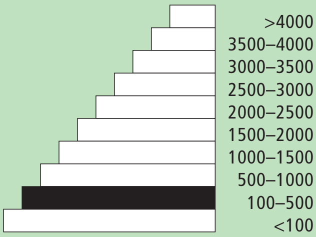
Environment

Natural environment

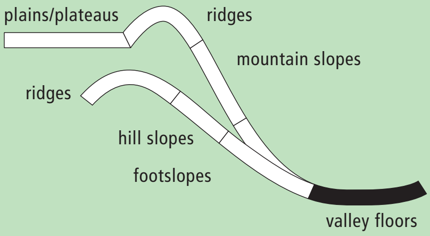
Average annual rainfall (mm)



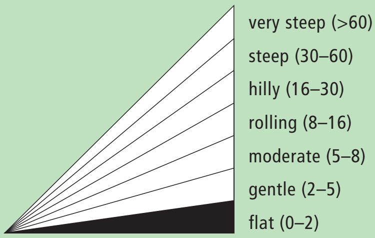
Altitude (m a.s.l.)



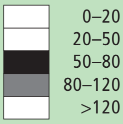
Landform



Slope (%)



Soil depth (cm)

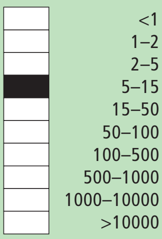


NB: soil properties before SWC

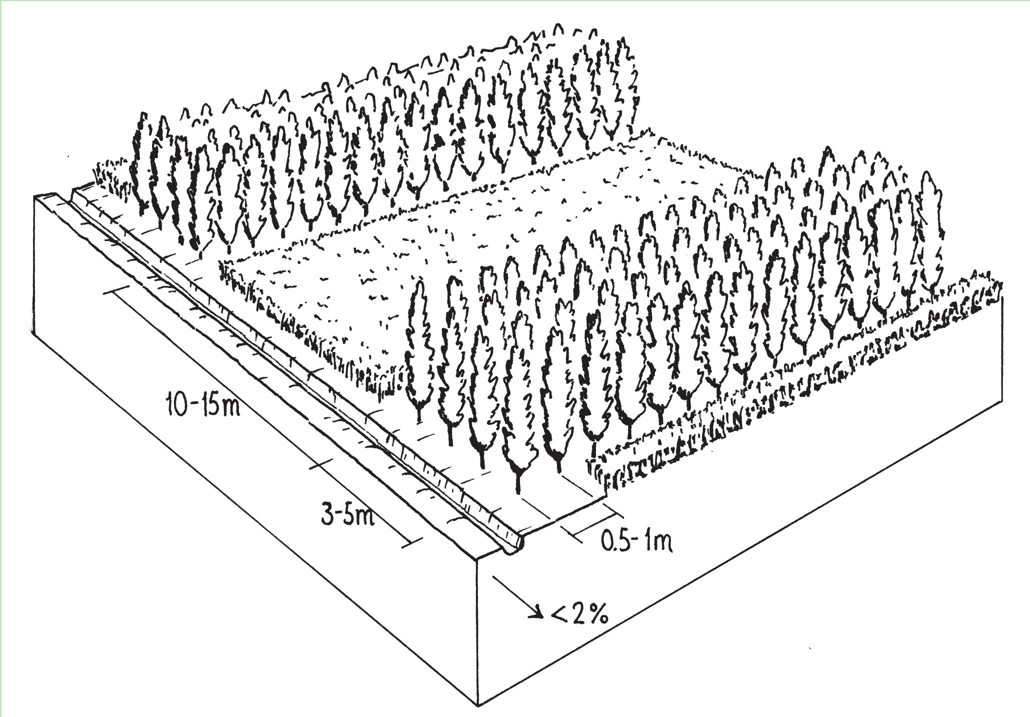
Growing season: 180 days (March to September)
Soil fertility: low to very low
Soil texture: medium (loam)
Surface stoniness: no loose stone
Topsoil organic matter: medium (1–3%)
Soil drainage: poor
Soil erodibility: soil degradation medium due to salinity and waterlogging.

Human environment

Mixed land per household (ha)



Land use rights: individual
Land ownership: individual titled
Market orientation: mainly subsistence (self-supply), little commercial (market): thinned poplar saplings, timber and firewood from prunings
Level of technical knowledge required: field staff/extension worker: moderate to high, land user: moderate
Importance of off-farm income: 10–50% of all income: this individual is an employee of the regional agricultural department and has a small business



Technical drawing
Alternating strips of poplar trees for bio-drainage, and lucerne for fodder. Drainage channels (left) are spaced at 50 metres apart.

Implementation activities, inputs and costs

Establishment activities

1. Set up tree nursery one year before planting: take cuttings about 25–30 cm long with 3 buds above the ground and plant.
2. Demarcate lines in field.
3. Dig drainage trenches in the marshy area (50 cm deep, 50 cm wide, 50 m apart) with tractor (end of summer, early autumn).
4. Plough where seedlings of the poplars are to be planted.
5. Transplant tree seedlings from the nursery to the field in spring.
6. Irrigate the seedlings by furrow for one year.
7. Protect the area from animals.
8. Plant lucerne (sown by machine in first year after planting of poplars).

Duration of establishment phase: 1–2 years

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour (150 person days)	350	100%
Equipment		
- Machines (ploughing, drainage: 30 hours)	100	100%
- Animal traction (transportation of seedlings)	5	100%
- Tools: shovel, axe, saw	15	100%
Agricultural		
- Seeds (10 kg)	20	100%
- Seedlings (about 3,000)	350	100%
- Nursery (preparation of land, weed control)	80	100%
TOTAL (rounded)	**920**	**100%**

Maintenance/recurrent activities

1. Prune lower branches of the trees to encourage tall and straight growth.
2. Continue protection of the plot (because of lucerne).
3. Cut lucerne for hay 4 times per year (mechanically).
4. Weed control by hand (main weeds are *Chenopodium album*, *Capsella bursa-pastoris*, and *Agropyron repens)*.

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Labour (10 person days)	25	100%
Equipment		
- Machines (2 hours)	5	100%
- Tools: shovel, axe, saw (already owned by farmer)	0	
TOTAL	**30**	**100%**

Remarks: Labour for establishment and maintenance are provided by the farmer and his family. After 10–15 years trees are thinned for timber and the cycle begins again – with reduced establishment costs: new saplings are planted between the existing, thinned, lines of poplars. On two sides the plot is protected by a drainage ditch and a concrete canal protect the plot respectively. Furthermore, there is an agreement with the neighbours not to let the animals graze the lucerne. However after the last cut of lucerne animals are allowed to graze the plot.

Assessment

Acceptance/adoption

A single farmer has developed this technology. It should be possible to spread the technology among other farmers but financial support (eg interest-free credit) will need to be provided. A recent assessment has showed that there is growing interest in the system by farmers in the region. Additionally, in the lower Yanvan Valley of Tajikistan, a similar bio-drainage system has been described - using poplars and mulberry trees. In that situation wheat is planted in association with the trees.

Benefits/costs according to land user

Benefits compared with costs	short-term:	long-term:
establishment	negative	very positive
maintenance/recurrent	positive	very positive

Impacts of the technology

Production and socio-economic benefits

- +++ wood production increase
- +++ increased crop production (after desalinisation of soil)
- ++ fodder production/quality increase (lucerne between tree lines)
- ++ farm income increase
- ++ reclamation of degraded land

Production and socio-economic disadvantages

- −− main benefit (timber) only after 10–15 years, however, short-term benefit from lucerne as fodder and from firewood through pruning
- − increased input constraints: not all the farmers have enough resources for introduction of this technology (equipment, seedlings)
- − increased labour constraints for establishment

Socio-cultural benefits

- +++ improved knowledge SWC/erosion

Socio-cultural disadvantages

none

Ecological benefits

- +++ draining of excess water and thus lowering of water table (1 m) through increased evapotranspiration
- ++ increase of soil fertility (due to lucerne: 100–130 kg of N are accumulated per 3 years; soil structure is improved, acidity is lowered, waterlogging and salinity are reduced)
- + biodiversity enhancement
- + reduction of wind velocity
- + increased air humidity (less dry and hot winds)

Ecological disadvantages

- − increased danger of fire

Off-site benefits

- ++ reduction in wind velocity
- ++ general drop of water table

Off-site disadvantages

none

Concluding statements

Strengths and ➜ how to sustain/improve

Positive ecological effect: salinity and area of marshy land can be reduced and waterlogged soils reclaimed ➜ Awareness raising and training of farmers to show the effect of poplar trees on reduction of waterlogging and salinisation.

Rapid benefit through the production of lucerne and grass. Long-term production of valuable firewood and timber (both are in short supply) ➜ Show the economic benefits of additional lucerne production and timber and firewood; demonstrate marketing opportunities.

Weaknesses and ➜ how to overcome

The implementation of the technology is not possible for all land users due to input and labour constraints ➜ Financial support, better organisation/share of equipment.

Major benefit from timber production comes only after 25 years ➜ Create awareness about additional short-term benefits, especially firewood and fodder, as well as the long-term effects and the sustainability of the system.

Cannot be replicated by all farmers in the valley at the same density as the market for trees (timber, firewood) will be saturated, and trees can never completely take the place of irrigated food crops: nevertheless the benefits will extend to those growers through the drainage function of the poplars ➜ A new overall production system will have to be worked out for the region.

The case reported here works in its current design because of its isolated ‘island effect’: if more farmer grew poplar, the same bio-drainage effect could be achieved over the whole valley at a lower density of trees per unit area, implying a larger proportion of cultivable land.

Key reference(s): Budaychiev D (2002) The prospects for hybrid poplar forest plantations. Resolving problems and the strategy of reforming agrarian science. *News of Kyrgyz Agrarian Academy* Vol. 2, Issue 3, 4.1 Bishkek

Contact person(s): Asanaliev Abdybek and Sydykbaev Talant, Kyrgyz Agrarian University, 68 Mederov St, 720005 Bishkek, Kyrgyzstan; phone ++996(312) 547894; asanaly61@mail.ru, s.talant_n@mail.ru ▪ Budaychiev Dair Kyrgyz Agrarian University, 68 Mederov St, 720005 Bishkek, Kyrgyzstan; phone ++996(312) 216279

left: General view of the multi-storey cropping system in the Philippines. The uppermost storey is coconut, followed by papaya, banana, coffee and pineapple. Root crops are grown underneath the coffee. (Jose D Rondal)
right: Taro in the lower layers of the multi-storey cropping system. 'Natural' mulching with leaves from leguminous trees. (Jose D Rondal)

Multi-storey cropping

Philippines – *Maramihang pagtatanim*

Cultivating a mixture of crops with different heights (multi-storey) and growth characteristics which together optimise the use of soil, moisture and space.

Under the *maramihang pagtatanim* multi-storey cropping system, perennial crops (coconut, banana, coffee, papaya, pineapple) and annuals/biennials (root crops: taro, yam, sweet potato etc) are interplanted to maximise productivity and income. This is most applicable where farms are small and the system needs to be intensive. In this particular area, Cavite, coconuts are usually planted first. When they reach a height of 4.5 meters (after 3–4 years), bananas, coffee and/or papaya are planted underneath. Black pepper may also be part of the system. After sufficient space has developed at ground level in about three to four years, root crops are planted. At full establishment, the system develops different layers: coconut (tallest) followed by banana, coffee, papaya (middle), root crops and pineapple (lowest). In recent years, because of its relatively low productivity and decreasing price, coconut has tended to be replaced in the system with higher value crops like the fruit tree *santol (Sandoricum koetjape),* papaya and sometimes black pepper. However most multi-storey farms adhere to no specific planting layout.

The multi-storey agroforestry system is intended to make the best use of resources (soil, moisture and space) for increased farm income. It is also very effective against soil erosion. Previously, continuous monocropping of annual crops resulted in erosion and serious soil fertility decline. Even though the land is sloping and rainfall during the monsoon is extremely intensive, multi-storey cropping provides adequate soil cover throughout the year, protecting the land from erosion.

Fertilization, weeding and pruning are necessary elements of maintenance. 'Natural' mulching through fallen leaves from leguminous trees helps restore and maintain soil fertility The system is applied in a volcanic-derived soil with distinct wet and dry periods (6 months wet season, 6 months dry season). There is the risk of a destructive typhoon every 10 years. Farm income is relatively high, but labour and input costs are also high – and the technology is mostly used by relatively wealthy landowners. There is strong spontaneous adoption, as *maramihang pagtatanim* has been proven to be effective and remunerative. This technology has been practiced in Cavite since the 1970s. Implementation is by individual farmers with strong extension support from the Local Government Units (LGUs), NGOs and the Cavite State University.

Location: Cavite, Philippines
Technology area: 40 km^2
SWC measure: vegetative and agronomic
Land use: cropland (before); mixed: agroforestry (after)
Climate: humid
WOCAT database reference: QT PHI07
Related approach: not documented
Compiled by: Jose Rondal, Quezon City, Philippines
Date: July 2001, updated July 2004

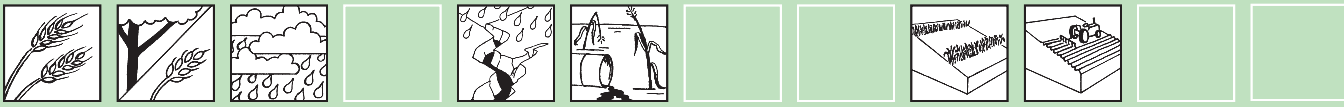
Editors' comments: Multi-storey cropping occurs in many parts of the world. It is a highly intensive and productive use of cropland, and is most often found in 'home gardens' of the subhumid and humid tropics. The system described here is a case study from Cavite, in the Philippines – with a combination of four or more crops in three main storeys. This system shares elements with the *Café arbolado* reported from Costa Rica.

Classification

Land use problems

Productivity decline, unstable prices of agricultural products and high costs of inputs are the main land use problems. Inputs also have to be increased to maintain the same yield level in annual cropping systems. There is a severe land use competition: a large proportion of the land is being converted to non-agricultural uses, especially residential and industrial areas because of the proximity to the rapidly expanding capital.

Land use | **Climate** | **Degradation** | **SWC measures**



annual crops: mainly vegetables (before) | agroforestry: various crops and trees (after) | humid | water erosion: loss of topsoil | chemical: fertility decline | vegetative: tree/shrub cover (multi-storey, aligned) | agronomic: better soil cover by vegetation, chem. fertilizer

Technical function/impact

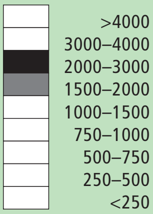
main:
- improvement of ground cover
- control of raindrop splash

secondary:
- control of dispersed runoff (impede/retard)
- increase in organic matter

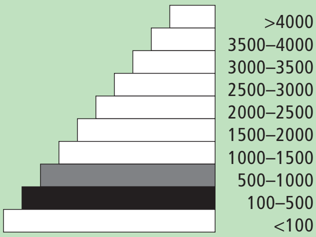
Environment

Natural environment

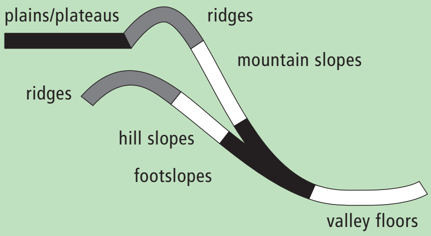
Average annual rainfall (mm)



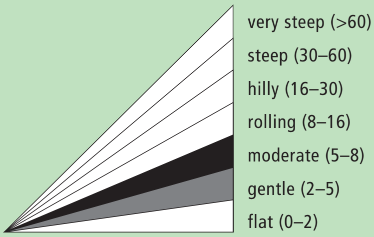
Altitude (m a.s.l.)



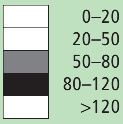
Landform



Slope (%)



Soil depth (cm)

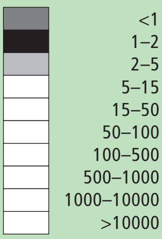


NB: soil properties before SWC

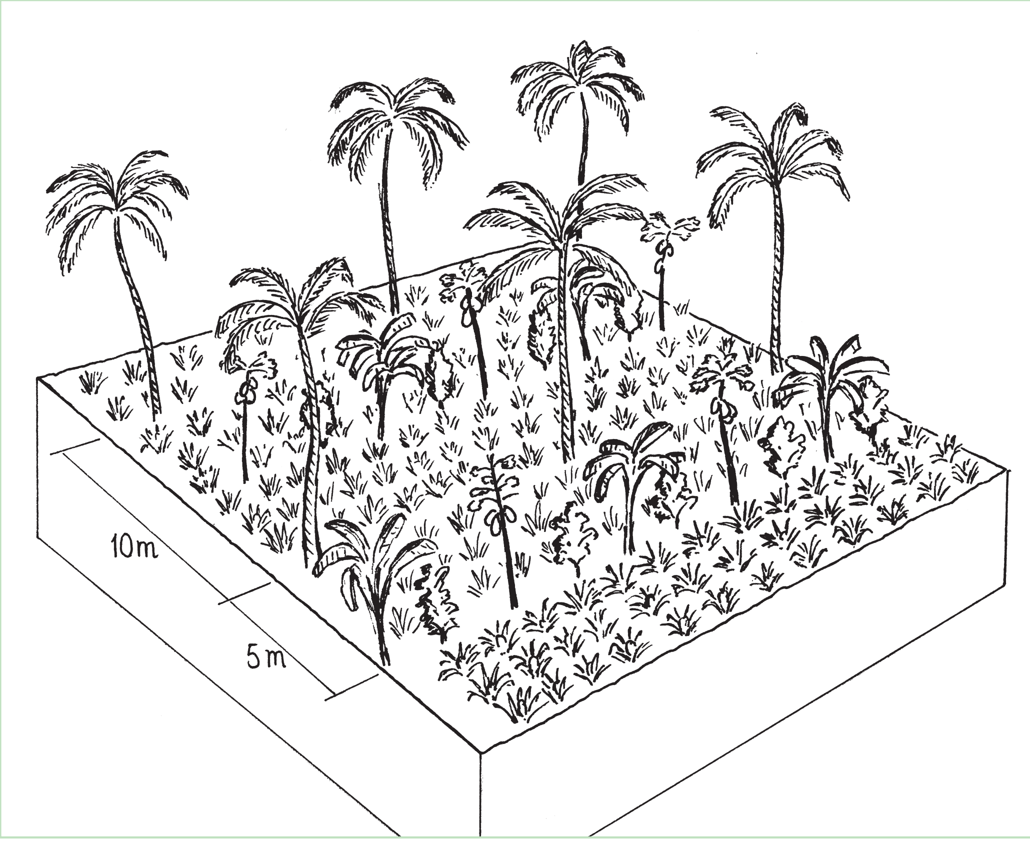
Growing season: 210–240 days (May to December/January)
Soil fertility: medium to high soil fertility; usually high in bases, medium to high organic matter and CEC, and neutral pH
Soil texture: medium (loam); soil derived from volcanic ash
Surface stoniness: some loose stone (no large rock)
Topsoil organic matter: medium (1–3%) to high (>3%)
Soil drainage: good structure for internal drainage
Soil erodibility: mostly medium (good structural strength)

Human environment

Mixed land per household (ha)



Land use rights: individual
Land ownership: individual titled
Market orientation: mainly commercial (about 80% is sold in the market), partly subsistence
Level of technical knowledge required: field staff/extension worker: moderate, land user: moderate
Importance of off-farm income: 10–50% of all income: remittances from employment of at least one member of the household. Trading is also important.



Technical drawing
Multi-storey cropping includes various species interplanted systematically to optimise use of resources: pineapple and other root crops (lowest storey); rows of banana trees, coffee and papaya (middle storey); rows of coconut (highest storey).
Note: in practice farmers adjust this layout to meet their needs.

Implementation activities, inputs and costs

Establishment activities

1. Planting of tallest storey (coconut).
2. Planting of middle storey (coffee and banana).
3. Planting of lowest storey (pineapple).
4. Planting of lowest storey continued (root crops).

All activities are carried out in the early rainy season by manual labour, using animal draft wooden plough, machete, iron bar and spade. Animal ploughing is used for pineapples. 'Natural' mulching through fallen leaves from leguminous trees helps restore and maintain soil fertility.
In some cases, all the crop components are planted at the same time. Coffee and banana are considered permanent (20 years for coffee) while papaya, pineapple and root crops are of shorter duration.
Duration of establishment: 4–5 years

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour (50 person days) only for land preparation and planting	150	100%
Equipment		
- Animal traction (32 hours)	50	100%
- Tools	40	100%
Agricultural		
- Seedlings	840	100%
- Fertilizers (1,000 kg)	160	100%
- Biocides (5 kg)	30	100%
- Compost/manure (1,000 kg)	120	100%
TOTAL	**1,390**	**100%**

Maintenance/recurrent activities

1. Pruning.
2. Weeding.
3. Harvesting.
4. Spraying.
5. Fertilizing.

Simple tools as machetes, wooden ploughs and harrows are used, as in the establishment phase.

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Labour (100 person days)	300	100%
Agricultural		
- Fertilizers (1,000 kg)	160	100%
- Biocides (5 kg)	30	100%
TOTAL	**490**	**100%**

Remarks: Cost was calculated assuming a per hectare population of 100 coconuts, 400 coffee plants and 3,000 pineapples. Maintenance activities entail more work than during the establishment phase. Note that the establishment phase usually lasts for 4–5 years, so the labour is spread, unlike during the maintenance phase when all of the components have to be attended to.

Assessment

Acceptance/adoption

All of the land users (1,000 families) who have implemented the technology have done it without incentives. These are landowners with a high income. There is strong spontaneous adoption as the technology has been proven to be very effective.

Benefits/costs according to land user

Benefits compared with costs	short-term:	long-term:
establishment	slightly positive	very positive
maintenance/recurrent	very positive	very positive

Impacts of the technology

Production and socio-economic benefits
- +++ crop yield increase due to high plant population (density)
- +++ farm income increase

Production and socio-economic disadvantages
- −−− increased labour constraints during planting/harvesting
- −−− increased input constraints (system is capital intensive)

Socio-cultural benefits
- +++ improved knowledge SWC/erosion
- ++ community institution strengthening through the formation of cooperatives or farmers organisation
- ++ national institution strengthening through the involvement of line agencies and strengthening of research component of research institutions

Socio-cultural disadvantages
- none

Ecological benefits
- +++ soil cover improvement (almost 100% soil cover)
- +++ increase in soil fertility (organic matter accumulation)
- +++ soil loss reduction (reduced runoff)
- + biodiversity enhancement
- + reduction of wind velocity

Ecological disadvantages
- none

Other benefits
- +++ increase in knowledge of crop production system, especially for small size farms

Other disadvantages
- none

Off-site benefits
- ++ reduced downstream flooding (reduced runoff)
- ++ reduced downstream siltation
- ++ reduced river pollution

Off-site disadvantages
- none

Concluding statements

Strengths and ➜ how to sustain/improve

Generates high farm income ➜ Continue strong extension service - especially for pest and disease control.

The technology is flexible. It can be modified to suit market condition. Failure of one crop component can be compensated by other components (improved food security) ➜ Try other high value crops as possible component of the system. Diversify further.

It maintains soil fertility through the recycling of nutrients ➜ Incorporate tree legumes in the system (eg gliricidia as support for black pepper).

It is a very effective way of using and conserving water ➜ Establish trash line along farm boundaries to add to this effect.

Strong research and development: because of its importance in the economy, the technology has spawned various research activities ➜ Adequate and sustained government support.

Weaknesses and ➜ how to overcome

High investment cost ➜ Government to provide low interest production loans (seeds, fertilizers).

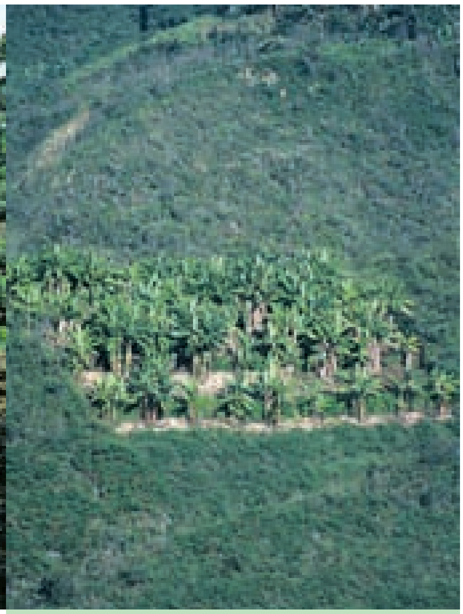
Highly fluctuating farm prices ➜ Spread out production schedule. Target off-season harvesting of crop (eg pineapple).

Pest and diseases (eg papaya virus, which may have developed because it has been part of the system for a long time) ➜ Intensified research and development.

Prone to typhoon damage ➜ Establishment of windbreaks: Leguminous trees such as Acacias could provide wind protection for lower crops like papaya or coffee.

High labour requirement (eg weeding, harvesting). Weeding may be reduced for some components (eg coffee), but pineapple always requires difficult (due to its thorny leaves) and intensive weeding ➜ (1) Use labour-reducing techniques (eg mulching), (2) spread activities over the growing season.

Key reference(s): FAO and IIRR (1995) *Resource management for upland areas in Southeast Asia.* FARM Field Document 2. Food and Agriculture Organisation of the United Nations, Bangkok, Thailand and International Institute of Rural Reconstruction, Silang, Cavite, Philippines.
Contact person(s): Jose Rondal, Bureau of Soils and Water Management, Diliman, Quezon City, Philippines; joserondal@yahoo.com



left: Combination of structural measures (multi-purpose ditches), vegetative measures (tree lines, grass strips) and agronomic measures (compost production, intercropping). (Mats Gurtner)
right: The highly integrated and diversified land use system is concentrated on a 0.4 ha plot, while adjacent land is left to regenerate naturally. The tree belt around the plot is not yet established. (Mats Gurtner)

Intensive agroforestry system

Colombia – *Silvoagricultura*

A protective and productive high-input agroforestry system comprising multi-purpose ditches with bunds, live barriers of grass, contour ridging, annual crops and fruit trees.

The intensive agroforestry system *(silvoagricultura)* combines traditional and newly developed practices adapted to the area's conditions. The idea is to concentrate cropping on a limited area, a plot of 0.4 ha per household, in a highly integrated, intensive and diversified continuous land use system, thereby integrating soil and water conservation – specifically avoiding traditional slash and burn practices.

Each 'agroforestry plot' comprises four to five 50 cm wide and 40 m long multi-purpose ditches that are excavated along the contour, 6 to 12 m apart, depending on the slope. The ditches retain runoff water which infiltrates the soil, thus reducing erosion and improving soil moisture. They also act as compost ditches for all types of organic residues on the farm. Residues, enriched with manure (from chickens and guinea pigs) are tipped into the ditches, and within 8 to12 months this decomposes into a fertile medium for the cultivation of vegetables and other crops.

Grass strips are planted on the earth bund on the upper side of the ditch for stabilisation of the structure, retention of runoff and capture of eroded sediment. The grass is cut several times a year to feed guinea pigs, which in turn recycle this into manure. On the lower side of the contour ditches, fruit trees and bananas are planted. Rows of multipurpose trees (mainly indigenous species) are planted around each agroforestry plot as a windbreak and for economic reasons: yielding fruit and timber. Between the structures, annual (and semi-perennial) crops are grown on hand-dug micro-terraces/ridges, again sited along the contour. Some farmers intercrop with legumes. Supportive technologies are protection of wells, afforestation and, where possible, irrigation to enhance production. Production is based on principles of organic farming.

High initial inputs of external manure are subsidised by the project (CISEC; see associated approach). The remainder of each farmer's land is left to natural regeneration, reforested, or where needed, used for conventional cropping. The main purpose is to increase and diversify production, and at the same time to protect natural resources and regenerate degraded areas.

The system is implemented on degraded and often steep slopes in subhumid areas where intensive rainfall and dry periods alternate. The land is officially owned communally (an 'Indigenous Reserve'), but land use rights are individual. The region has a high population density: people are basically of indigenous origin and live in very poor conditions.

Location: Resguardo Indígena Las Canoas, Santander de Quilichao, Cauca, Colombia
Technology area: 1.2 km^2
SWC measure: structural, vegetative and agronomic
Land use: wasteland (before), mixed: agroforestry (after)
Climate: subhumid
WOCAT database reference: QT COL02
Related approach: Integrated rural community development, QA COL02
Compiled by: Jairo Cuervo, CISEC, Cali, Colombia
Date: July 1998, updated July 2004

Editors' comments:
This new and promising high-input agroforestry system combines traditional and new elements in relation to Colombia. The emphasis is on protection with production. There are interesting similarities with agroforestry systems reported from Kenya, Costa Rica and the Philippines.

Classification

Land use problems
- soil degradation/reduced soil fertility
- inappropriate soil management: monoculture, slash and burn, no or short fallow periods
- intensive rainfall on steep, unprotected slopes
- drought and wind erosion in dry season
- lack of economic resources
- high population density

Land use

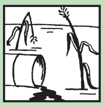

wasteland: degraded land (before)


agroforestry: fruit trees, bananas, maize, legumes (after)

Climate


subhumid

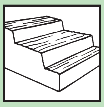
Degradation

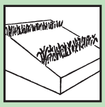

chemical: fertility decline

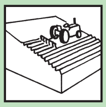

water erosion: loss of topsoil


wind erosion: loss of topsoil

SWC measures


structural: level bunds/ ditches; micro-terrace


vegetative: aligned trees, grass strips


agronomic: compost, intercropping, manuring

Technical function/impact

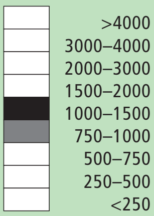
main:
- control of dispersed runoff
- increase in organic matter
- reduction of slope length
- increase/maintain water stored in soil
- increase in soil fertility

secondary:
- improvement of ground cover
- control of raindrop splash
- reduction in wind speed
- increase of infiltration
- reduction of slope angle
- sediment harvesting

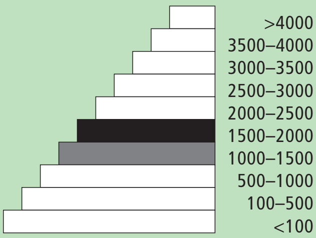
Environment

Natural environment

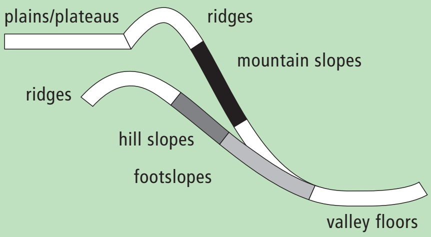
Average annual rainfall (mm)



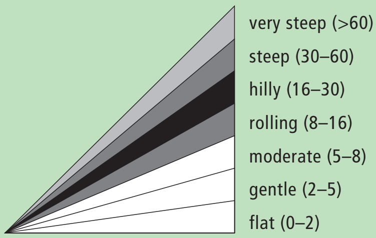
Altitude (m a.s.l.)



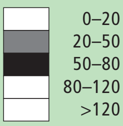
Landform



Slope (%)



Soil depth (cm)

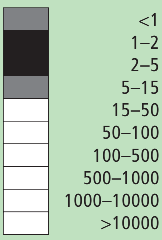


NB: soil properties before SWC

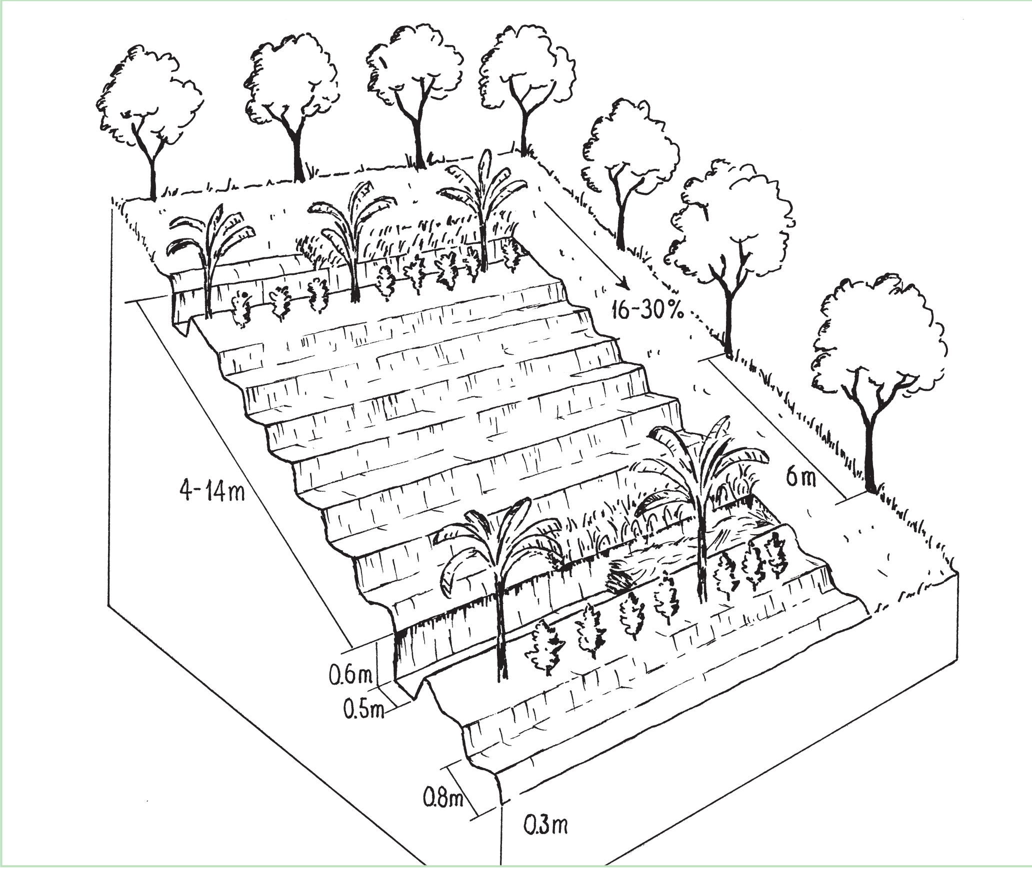
Growing season: 240 days (October to May)
Soil fertility: medium
Soil texture: mostly coarse (sandy), partly medium (loam)
Surface stoniness: mostly no stone, partly some/abundant loose stone
Topsoil organic matter: mostly medium (1–3%), partly high (>3%)
Soil drainage: good
Soil erodibility: medium

Human environment

Mixed land per household (ha)



Land use rights: mostly individual, partly communal (organised)
Land ownership: mostly communal/village, partly individual not titled
Market orientation: mostly subsistence (self-supply), partly mixed (subsistence/commercial)
Level of technical knowledge required: field staff/extension worker: high, land user: moderate
Importance of off-farm income: <10% of all income: most farmers depend economically entirely on their own crop production



Technical drawing
Detailed overview of the complex and intensive high-input, high-output agroforestry system, usually limited to an area of 64 x 64 metres. The agroforestry plots are bordered by trees of various species. Note the multipurpose ditches that serve as compost pits (lower ditch, right). Associated bunds are covered by grass (right).

Implementation activities, inputs and costs

Establishment activities

During the dry season (June to September):

1. Clear land (only slashing, no burning).
2. Determine contours with A-frame, spacing between structures depends on slope (4 m between ditches on steepest slopes, 14 m on gentle slopes).
3. Dig ditches, build bunds above, and dig holes for tree seedlings.
4. Establish micro-terraces/ridges (earth enriched with manure and residues: all structures along the contour).
5. Fill ditches with organic residues, adding earth mixed with manure.

Beginning of rainy season (April):

6. Plant grass strips on the bund (for stabilisation of structure).
7. Plant fruit/banana trees and legumes below the bunds.
8. Plant fruit and timber trees along the boundaries of the agroforestry plot (life fence/wind break).

Duration of establishment: 1 year

Establishment inputs and costs per plot*

Inputs	Costs (US$)	% met by land user
Labour (44 person days)	220	100%
Equipment		
- Tools: machete, shovel, pickaxes, A-frame, planting stick (chuzo)	0	
Agricultural		
- Seeds (6 kg)	15	5%
- Seedlings (920)	450	5%
- Compost/manure (14 t)	600	5%
TOTAL	**1285**	**21%**

Maintenance/recurrent activities

1. Cut grass (4–6 times/year, grass used to feed guinea pigs).
2. Control weeds (3 times/year).
3. Rebuild/repair structures (dry season).
4. Fill ditches with organic material, residues (after harvest), manure, etc and let it decompose.
5. Plant vegetables on fertile composted earth in ditches (dry season, optional).
6. Dig out compost and spread (beginning of growing season (September).
7. Apply additional fertilizer/manure (3 times/year).
8. Plant various crops: contour cropping, intercropping, integrate green manures (legumes).

Maintenance/recurrent inputs and costs per plot* per year

Inputs	Costs (US$)	% met by land user
Labour (20 person days)	100	100%
Equipment:		
- Tools: machete, shovel, etc	0	
Agricultural		
- Fertilizers (1,000 kg)	45	100%
TOTAL	**145**	**100%**

* plot size is 0.4 ha

Remarks: As an exception in this case study costs are calculated per plot and not per ha, since establishment is strictly limited to an area of 0.4 ha per household. The remaining area is not treated but left for natural regeneration of vegetation or conventional farming (if needed). Labour costs vary according to slope: a typical/average situation is given in the tables above (no further details available). Note that for comparison purposes with other technologies on a per hectare basis these costs would equate to US$ 3,135 for establishment and US$ 355 for maintenance.

Assessment

Acceptance/adoption

- All of the land users who accepted the technology (260 families) did so with incentives.
- The project gives educational assistance, training, technical assistance in the field, manure and seeds/seedlings and the starting capital for a revolving fund that helps in buying the inputs needed to maintain the initiative (this fund is managed by the land users themselves). In exchange the land users have to work on the demonstration areas of the local research plots of the investigation centre (CISEC). They also have to meet the conditions implemented by the project (timing of activities, layout of technology, etc).
- There is a slight growing spontaneous adoption by land users living outside the approach area.

Benefits/costs according to land user

Benefits compared with costs	short-term:	long-term:
establishment	positive	very positive
maintenance/recurrent	positive	very positive

Impacts of the technology

Production and socio-economic benefits

+++	crop yield increase
++	fodder production/quality increase
++	improved nutrition (household level)
+	farm income increase
+	wood production increase

Production and socio-economic disadvantages

−−	increased labour constraints
−	increased economic inequity
−	increased input constraints

Socio-cultural benefits

+++	improved knowledge SWC/erosion
++	community institution strengthening

Socio-cultural disadvantages

−	socio-cultural conflicts (friction between participants and non-participants)

Ecological benefits

+++	soil loss reduction
+++	biodiversity enhancement
+++	increased diversification
++	soil cover improvement
++	increase in soil moisture
++	increase in soil fertility
++	increase in pest control
+	reduction of wind velocity

Ecological disadvantages

−−	increased soil acidity (high content of organic matter)

Off-site benefits

+	reduced transported sediments
+	reduced downstream siltation
+	reduced river pollution

Off-site disadvantages

−	reduced river flows (use of water for irrigation)

Concluding statements

Strengths and ➜ how to sustain/improve

Rehabilitation of soil fertility over short term ➜ Continue to use the ditches for compost production.

Increased and permanent production ➜ Constant maintenance.

Increased food security and balanced diet ➜ More diversification.

Reduction of erosion processes ➜ Improve the soil cover through implementation of green manure and cover crops.

Adapted to very heterogeneous climatic and topographic conditions.

Protective-productive system: compromise between land capability class (forest) and cultivation needs ➜ Consistent maintenance of all elements that interact in this agroforestry system: trees, grass strips, earth structures, compost production and green manure.

Weaknesses and ➜ how to overcome

Rigid design of the technology and fixed guidelines for implementation activities (pre-conditions for incentive support by project) ➜ Give more flexibility to the farmers for individual modifications.

High demand for manual labour ➜ Emphasis on group work, implement in dry season (when labour force is available at the household level).

High external inputs at the beginning (makes the technology very expensive) ➜ Manure is needed to restore soil fertility in the short-term, land users pay the inputs in form of labour in the CISEC; revolving funds and composting ensure manure supplies on the long term.

Decreased pH (soil acidity) ➜ Compensate by ecological improvements such as application of lime and ashes.

Key reference(s): CISEC (1998) *Establecimiento de Lotes de Silvoagricultura* ■ Gurtner M (1999) *Bodendegradierung und Bodenkonservierung in den Anden Kolumbiens – Eine Nachhaltigkeitsstudie im Rahmen des WOCAT-Programms,* unpublished MSc Thesis, Science Faculty, University of Berne, Centre for Development and Environment

Contact person(s): Eduardo Caicedo, Calle 4B* 95–82 Barrio Melendez, Cali, Colombia; phone/fax 092-3320067/ 3324640/ 3326779; ecaicedo@emcali.net.co, alternativacomunitaria@telesat.com.co

left: Local promoters (trainers) participating in a three day workshop at the Centre for Research and Community Services – CISEC. Different topics related to sustainable land use are treated. (Mats Gurtner)
right: The approach area is characterised by severe erosion and fertility decline. The promoted technology limits agricultural production to a small but intensively used area. (Mats Gurtner)

Integrated rural community development

Colombia – *Desarrollo rural integral comunitario*

Development of an impoverished indigenous reserve – incorporating alternative land use systems – through intensive training provided by a small NGO.

The Foundation for Rural Community Development is a small NGO, working in a 5 km^2 indigenous reserve – characterised by ecological and economic crises. In this area, the foundation has built up a Centre for Research and Community Services (CISEC – *Centro de Investigacion y Servicios Comunitarios).*

CISEC operates an experimentation and training centre in the reserve, where large demonstration/production areas also exist. For 15 years CISEC has provided training to local promoters in the fields of sustainable land use and health care. Workshops are held, and a team of specialists guarantee continuous supervision and technical assistance for the land users. The specialists plan the approach and the development of the technology. Its design, and the precise implementation steps are clearly prescribed.

The overall purpose of the approach is to raise the living standard of the marginalized indigenous people through alternative development opportunities. This is achieved by focussing on four principle areas: (1) Promoting an alternative land management system ensuring sustained and diversified production based on the principles of organic farming (see related technology: 'intensive agroforestry system'); (2) Improving basic health services, sanitation and promoting balanced nutrition; (3) Training, education and capacity building at three levels: (a) integration of sustainable land management as a topic in the local college – directed by CISEC; (b) basic training on technology implementation, ecological processes and accounting for all participants; (c) special workshops to train local promoters who continue to advise land users after the implementation stage through various means, including development of teaching materials, libraries, workshops, courses, farm visits, and demonstration sites. (4) Economical dimension: a new initiative within the programme focuses on marketing of organic products.

Participating land users have to adhere to specific requirements and fulfil certain conditions. For example, the layout of the agroforestry system has to be done to plan, groups must be organised, and a schedule for implementation developed. Participatory identification of problems and needs takes place in community assemblies, and through individual talks between extensionists and land users. To facilitate the implementation and ensure the continuation of SWC practices, land user groups manage a revolving fund – based on the subsidised provision of manure ('manure-for-work') during the establishment phase of the technology.

Location: Resguardo Indígena Las Canoas, Santander de Quilichao, Cuaca, Colombia
Approach area: 5 km^2
Land use: wasteland (before), mixed: agroforestry (after)
Climate: subhumid
WOCAT database reference: QA COL02
Related technology: Intensive agroforestry system, QT COL02
Compiled by: Jairo Cuervo, CISEC, Cali, Colombia
Date: July 1998, updated July 2004

Editors' comments: In many parts of the world NGOs are taking responsibility for reaching rural indigenous peoples and helping them to help themselves. The first experience was in an indigenious reserve in Southern Columbia. Further extension is being carried out through a network of local NGOs, and there is some spontaneous adoption in nearby areas.

Problem, objectives and constraints

Problem
- high level of unsatisfied basic needs
- land degradation
- lack of technical and social infrastructure
- lack of support from outside

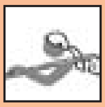
Objectives
- achieve sustainable and efficient use of local resources
- improve the living standard of the indigenous population
- strengthen land users' organisations
- promote land rehabilitation and increase agricultural production
- promote environmental education through training of the community

Constraints addressed

Major	Specification	Treatment
Legal	Land fragmentation leads to small-sized properties; access to water is limited.	Construction of small private water tanks.
Financial	Lack of economic resources.	Land users are provided with subsidised inputs during establishment phase.
Minor	**Specification**	**Treatment**
Social/cultural/religious	Slow adoption of technologies at the beginning; reluctance and prejudice towards the white specialists from outside; difficulty in convincing local leaders.	Discussions with interested land users, farmer-to-farmer interaction.

Participation and decision making

Target groups


Land users


Teachers/ students

Approach costs met by:

International NGO: Helvetas (Switzerland)	55%
National NGO	5%
Community/local	40%
	100%

Decisions on choice of the technology: Mainly made by SWC specialists with consultation of land users, through experimentation and development of the technology by CISEC (including traditional elements) and consulting the needs of the land users.
Decisions on method of implementing the technology: Mainly made by SWC specialists with consultation of land users: implementation of the technology according to directives of CISEC (regarding implementation steps and time-schedule). Modifications by land users only regarding the selection of crops.
Approach designed by: National and international specialists.

Community involvement

Phase	Involvement	Activities
Initiation	passive	experimentation and demonstration of the technology on test areas, participatory identification of problems and needs in assemblies and individual discussions
Planning	passive	planning of the approach and technology implementation steps by specialists; for planning of workshops the land users are consulted regarding their needs
Implementation	interactive	the land users implement the technology on their own, organised in groups, supported and assisted by the local promoters and by the CISEC specialists
Monitoring/evaluation	interactive	continued assistance and supervision by the specialists by means of farm visits, evaluations and reports (by CISEC and local promoters); during workshops observations made by land users are evaluated
Research	passive	research activities take place basically on CISEC's plots, some experimentation is carried out on the land users' farms; there is integration of land users' ideas into the investigation process

Differences in participation of men and women: There are moderate differences between the roles of men and women originating from *machismo* – the traditional relationships between (and roles of) men and women. While the difference currently is quite pronounced, the participation of women is increasing.

A local promoter, a land user who was trained by the Research Centre CISEC to extend the agroforestry system within the approach area, demonstrates different steps of technology implementation: demarcation of the contour lines using A-frame, pegs and rope, and digging of an infiltration ditch. His son, who is assisting, will soon learn about, and practice, sustainable land management practices at the rural college, which was established and is managed through the programme. (Mats Gurtner)

Extension and promotion

Training: Training is carried out in agroforestry, livestock management, protection and sustainable use of forests, soils, watershed management, organic weed control (spraying organic liquids), basic accounting, and nutrition. This is done through courses, demonstration areas and farm visits. The training of local promoters has been very effective, and the impact on land users and students is said to be good.
Extension: Workshops and farm visits are the main means of extension. Key element of extension method is the training of local promoters who pick up extension activities in the community after the implementation phase has been completed, thus guaranteeing the continuation of extension services in the long term. So far, the impact of extension on land users and specialists has been good.
Research: Experimental investigation takes place on the demonstration plots of CISEC: there have been variety trials, and testing of SWC measures. The impact of research has been considerable.
Importance of land use rights: Land use rights are secure in the long term, thus no negative impact on approach or technology has been observed.

Incentives

Labour: Labour was mainly voluntary.
Inputs: Initial inputs of seeds, seedlings, manure, biocides and construction material for irrigation infrastructure were subsidised by the project for establishment of the agroforestry system. Farmers pay for those inputs through working for CISEC (on CISEC's production and demonstration areas). A basic stock of manure is provided by the project to establish a revolving fund to ensure the continuation of the SWC activities.
Credit: No credit was provided.
Support of local institutions: Considerable support to local institutions was given in the form of training.
Long-term impact of incentives: A moderate positive long-term impact is expected: through initial incentives land users have begun to notice the changes: this motivates them to continue in the same direction. Moreover, CISEC provides continued support to the land users by providing inputs at low prices. However some land users only participate in order to benefit from initial free manure provision.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	regular qualitative soil assessment
Technical	regular observations of design modifications
Economic/production	regular accounting of costs and benefits
Area treated	ad hoc counts of agroforestry plots
No. of land users involved	regular counts of participants
Management of approach	regular revision of distribution of limited project resources

Impacts of the approach

Changes as result of monitoring and evaluation: There have been several changes: these include schedule of technology implementation, incentives, the integration of animals into the production systems, training on specific topics that have been identified as important (maintenance of particular measures, keeping of accounts, etc).
Improved soil and water management: Soil and water management has improved very much. Land users have implemented the agroforestry system, which combines different measures to control soil erosion, restore soil fertility, and improve soil water holding capacity.
Adoption of the approach by other projects/land users: None.
Sustainability: Land users can continue activities initiated under the approach without further external support. The revolving fund helps them to access the necessary inputs, and technical assistance is available through the trained local promoters. SWC specialists from CISEC also follow up and monitor the implemented SWC practices during frequent farm visits.

Concluding statements

Strengths and ➜ how to sustain/improve	**Weaknesses** and ➜ how to overcome
Training of land users and of local promoters (human capacity building) ➜ Maintain activities.	There are land users who participate only to receive manure for work (negative impact of incentives) ➜ Put more emphasis on on-farm manure/compost production.
Improve agricultural production through utilisation of local resources ➜ Maintain activities.	Lack of awareness raising and training in some important topics (eg green manuring etc) ➜ Strengthen training.
Strengthen self-sufficiency/independence of the community ➜ Maintain activities.	The design and implementation processes of the technology are rather fixed and static ➜ Allow more possibilities for modification by land users.
'Involvement' of the land users by responding to their needs.	The 'manure-for-work' system is limited to the first year for each participant; afterwards some land users find it difficult to get access to manure.
Sustained and/or increased agricultural production and marketing of 'healthy', organic products.	Very labour intensive technology design (but already overcome by provision of incentives and implementation in organised groups) ➜ Emphasise production increase as an incentive.

Key reference(s): Gurtner M (1999) *Bodendegradierung und Bodenkonservierung in den Anden Kolumbiens – Eine Nachhaltigkeitsstudie im Rahmen des WOCAT-Programms,* unpublished MSc Thesis, Science Faculty, University of Berne, Centre for Development and Environment
Contact person(s): Eduardo Caicedo, Calle 4B* 95–82 Barrio Melendez, Cali, Colombia; phone/fax 092-3320067/ 3324640/ 3326779; ecaicedo@emcali.net.co, alternativacomunitaria@telesat.com.co


left: An overview showing variations of the technology with different levels of tree cover and different stages of coffee growth: newly established (upper left) and well-developed coffee (lower right). (Esther Neuenschwander)
right: Coffee planted along the contour, associated with banana and other fruit trees. Additional measures such as dense strips of lemon grass protect the soil from erosion. (Esther Neuenschwander)

Shade-grown coffee

Costa Rica – *Café arbolado*

An agroforestry system which combines coffee with shade trees – including fruit, timber and leguminous species – in a systematic fashion.

Shade-grown coffee is a traditional and complex agroforestry system where coffee is associated with various other species in different storeys (or 'levels'). This provides ecologically and economically sustainable use of natural resources. *Café arbolado,* the example promoted by PRODAF (Programme for Agroforestry Development, see related approach: 'Agroforestry Extension') since 1987 is one technical option for shade-grown coffee.

While based on a traditional system the shade-grown coffee technology has a specific layout, and a reduced number of intercropped species. It comprises: (1) Coffee *(Coffea arabica)* planted on the contour at approximately 5,000 plants per hectare; (2) Associated trees: fruits, most commonly oranges (120 trees/ha), cedar *(Cedrela odorata)* or *caoba (Swietenia macrophylla)* for timber (60 trees/ha) and also two legumes, *poró (Erythrina poeppigiana)* and *chalum (Inga sp.)* which act as shade trees and at the same time improve the soil by fixing nitrogen (60 trees/ha). Farmers often include bananas in the system. In some cases, orange trees have partly been substituted by avocado *(Persea americana), soursop (Anona muricata),* and/or *jocotes (Spondias purpurea).* The latter two command good market prices and do not compete with labour needed for harvesting and other activities; (3) Supportive soil conservation measures on steep slopes to avoid soil erosion, predominantly strips of lemon grass *(Cymbopogon citratus)* on the contour, retention ditches and soil cover improvement; (4) Fertilizers: both organic and inorganic combined.

Full establishment of a shaded coffee plot can be achieved in two years – after replanting trees which fail to establish. Coffee yields a harvest after two years, but timber from associated trees can be expected after only 25 years. The trees grown in association allow more efficient cycling of nutrients (because of deep rooting and nitrogen fixation) and provide a favourable microclimate for coffee.

This production system is well adapted to the local biophysical and socio-economic conditions, characterised by steep erosion-prone mountain slopes, humid climate and small to medium scale agriculture. Based on *café arbolado* a new, and further developed system of 'sustainable coffee' has evolved. This involves certification of the overall process and is attractive to the growing number of environmentally conscious consumers.

Location: Acosta-Puriscal, San José/Río Parrita, Costa Rica
Technology area: 400 km^2
SWC measure: vegetative and agronomic
Land use: mixed: agroforestry
Climate: humid
WOCAT database reference: QT COS02
Related approach: Agroforestry extension, QA COS02
Compiled by: Quiros Madrigal Olman, Puriscal, Costa Rica
Date: August 2001, updated July 2004

Editors' comments: About three quarters of Costa Rica's coffee is grown in association with shade trees. The expanding international market for coffee produced in an environment-friendly way opens further opportunities for shade-grown coffee. This agroforestry system differs from the less systematically managed 'forest coffee' commonly practiced in the region.

Classification

Land use problems

Severe deforestation, inappropriate land management practices (monocultures on steep slopes; lack of conservation measures); resulting in physical (soil erosion) and chemical (fertility decline) degradation of agricultural soils, low productivity and low yields.

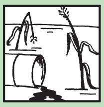
Land use

agroforestry: coffee and various trees

Climate

humid

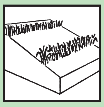
Degradation



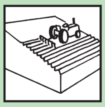
chemical: fertility decline

water erosion: loss of topsoil, land slides

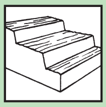
SWC measures



vegetative: aligned trees, grass strips



agronomic: mixed cropping, organic/chem. fertilization



structural: retention ditches (supp.)

Technical function/impact

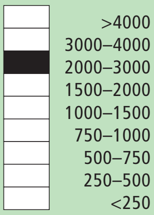
main:
- improvement of ground cover
- increase in soil fertility
- increase in organic matter
- increase of infiltration

secondary:
- control of raindrop splash
- control of concentrated runoff
- control of dispersed runoff

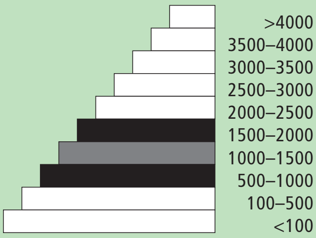
Environment

Natural environment

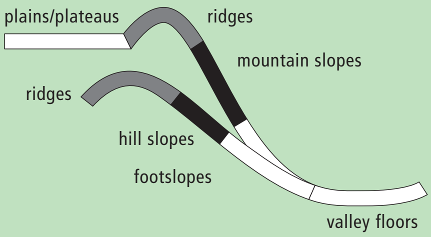
Average annual rainfall (mm)



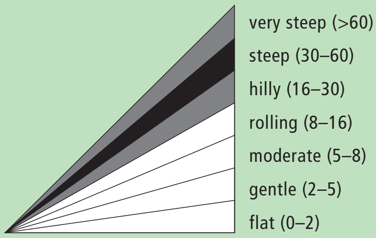
Altitude (m a.s.l.)



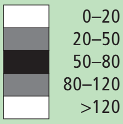
Landform



Slope (%)



Soil depth (cm)

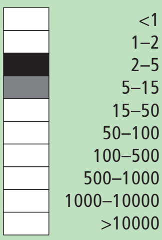


NB: soil properties before SWC

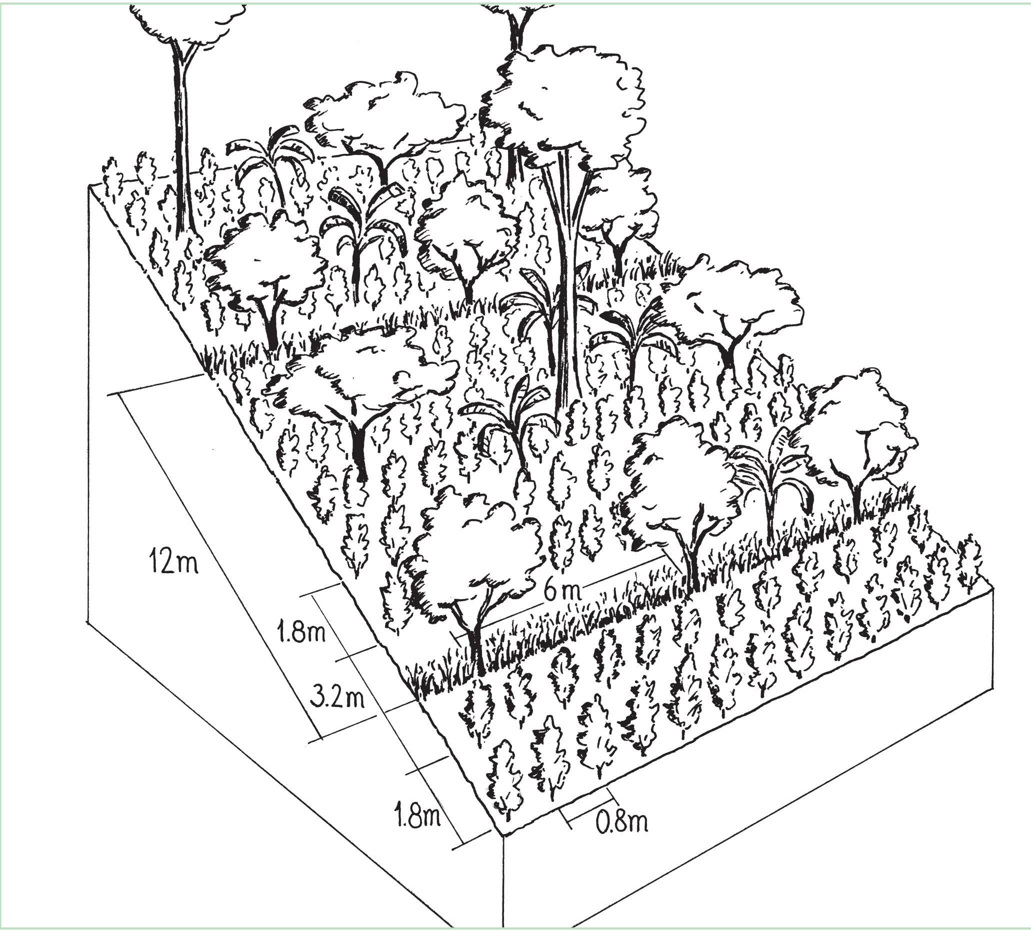
Growing season: 270 days (April to December)
Soil fertility: mostly low, partly moderate
Soil texture: mostly fine (clay), partly medium (loam)
Surface stoniness: some loose stone, partly no loose stone
Topsoil organic matter: mostly high (>3%), partly medium (1–3%)
Soil drainage: mostly good, partly medium
Soil erodibility: mostly high, partly medium

Human environment

Mixed land per household (ha)



Land use rights: individual
Land ownership: mostly individual titled, partly individual untitled
Market orientation: mostly mixed (self-supply and commercial)
Level of technical knowledge required: field staff/extension worker: high, land user: high
Importance of off-farm income: 10–50% of all income: subdivision of land (through inheritance), improved communications linking the capital with rural areas, and a better system of education all provide for increased off-farm income earning opportunities



Technical drawing
Example layout of coffee grown below shade trees: various species are used for shade, and each has intrinsic value of its own – orange trees (for fruit) are associated with strips of lemon grass, tall cedars (for timber) are planted in rows alternating with *Erythrina sp*. (for fertility improvement). Optionally, banana trees are interplanted.

Implementation activities, inputs and costs

Establishment activities

1. Clearing of land.
2. Surveying for contour planting of coffee, grass strips, trees etc.
3. Digging holes, fertilizer application.
4. Planting coffee, trees, grass barriers etc along the contour.
5. Replanting coffee that fails to establish in first year.

All activities are carried out at beginning of rainy season (March/April).
Duration of establishment: 2 years

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour (100 person days)	700	100%
Equipment		
- Tools (shovel, machete)	0	
Agricultural		
- Seedlings: *poró*/cedar (approx. 150)	15	0%
- Seedlings: orange trees (approx. 150)	220	0%
- Seedlings: coffee (5,000 initially + 500 replanted = 5,500)	1240	0%
- Fertilizers (8,000 kg)	350	0%
Others		
- Transport	10	0%
TOTAL	**2535**	**28%**

Maintenance/recurrent activities

1. Weed control (June and August).
2. Pruning coffee (February or March).
3. Fertilization (1–3 times: May, July, November).
4. Pest control (spraying 1–2 times: May, September).
5. Pruning shade trees.
6. Application of lime.

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Labour (4 person days)	28	100%
Equipment		
- Tools (knapsack, machete)	0	
Agricultural		
- Fertilizers (500 kg)	175	100%
- Biocides (4 kg)	127	100%
TOTAL	**330**	**100%**

Remarks: The costs of planting coffee are included. Shade-grown coffee is an integrated production system, and thus costs for coffee and the agroforestry component cannot be disaggregated.

Assessment

Acceptance/adoption

- All the land users who accepted the technology did so with incentives.
- Those land users received incentives in form of donated seedlings (for coffee, fruit and timber trees) and subsidised agricultural inputs for the establishment of agroforestry plots. Tools were only provided when absolutely necessary.
- There is a slight trend towards growing spontaneous adoption – after the end of the programme. However, the crisis triggered by the big drop in coffee prices has had a negative impact on adoption of the technology. Many coffee farms have been abandoned specially those located under 800–900 m a.s.l. where coffee is of a lower quality due to climatic conditions.

Benefits/costs according to land user

Benefits compared with costs	short-term:	long-term:
establishment	negative*	positive
maintenance/recurrent	positive	very positive

*establishment costs are high, but after 5 years the system becomes very profitable.

Impacts of the technology

Production and socio-economic benefits

+++	crop yield increase (fruits)
+++	wood production increase (trees)
++	improved profitability

Production and socio-economic disadvantages

–	reduced production: coffee, about 10% less than in conventional systems (per ha per year)
–	increased labour constraints

Socio-cultural benefits

+++	improved knowledge SWC/erosion
++	national institution strengthening

Socio-cultural disadvantages

– –	lack of incentives for technology adoption
–	socio-cultural conflicts

Ecological benefits

+++	soil loss reduction
+++	soil cover improvement
++	increase in soil moisture
++	increase in soil fertility
+	biodiversity enhancement
+	reduction of wind velocity

Ecological disadvantages

none

Off-site benefits

++	reduced downstream flooding

Off-site disadvantages

none

Concluding statements

Strengths and ➜ how to sustain/improve

- Increased overall crop production and diversity: coffee, fruit, timber, legumes ➜ Include other legumes, native species.
- Different crops harvested at different periods, gives better distribution of labour (and income) throughout the year; participation of all family members; increased food security and minimal economic risk ➜ Maintain the system well.
- Improved profitability.
- More efficient use of nutrients, nitrogen fixation, lower inputs of fertilizers.
- Increased pest resistance, lower external inputs of biocides.
- Coffee plants continue to produce over 25 years due to optimal microclimate (only 15 years in conventional system without trees).
- Production system adapted to steep erosion prone slopes, thus a productive alternative to simple afforestation.
- Not labour-intensive compared with structural measures of SWC.
- High commercial potential of environmentally friendly produced coffee due to new market trends.
- Price increase for agricultural inputs has favoured a shift from conventional to shade-grown coffee, the latter being a system with a higher ratio of applied inputs/harvested yields although total production is usually lower than in modern coffee plantations.

Weaknesses and ➜ how to overcome

- Slight decrease in production of coffee per hectare compared to the conventional pure stand ➜ Compensate by additional benefits: wood production, fruit, etc.
- Short-term negative cost-benefit ratio in the first 4–5 years: Cost-intensive technology in the establishment phase.
- Timber harvest only in the long term (after 25 years) ➜ Identify fast growing species or species providing intermediate products.

Key reference(s): PRODAF (1994) *Sistema agroforestal – Café arbolado,* Ecología y economía para el progreso, Puriscal, Costa Rica ▪ Neuenschwander E (2002) *Agorforstwirtschaftlicher Kaffeeanbau als Lösungsansatz für eine ökologisch nachhaltige Bodennutzung der Hanglagen in Costa Rica: eine Fallstudie im Rahmen des WOCAT Programms,* unpublished MSc thesis, Science Faculty, University of Berne, Centre for Development and Environment

Contact person(s): Quiros Madrigal Olman, *Ministerio de Agricultura y Ganadería,* Santiago de Puriscal, 85-6000 Puriscal, Costa Rica; phone ++ 506 416 87 35, fax ++ 506 416 87 38; ojquiros@yahoo.com

left: Discussion between farmers and extensionists during a workshop organised by the Ministry of Agriculture and Livestock. (Esther Neuenschwander)
right: Coffee seedlings ready to be planted. Seedlings for coffee, fruit trees and grass strips are provided free of charge to the land users who implement the agroforestry system. (Esther Neuenschwander)

Agroforestry extension

Costa Rica – *Extensión agroforestal*

Participatory extension of agroforestry systems, especially of shade-grown coffee, to promote sustainable and productive use of natural resources among small and medium scale farmers.

The Programme for Agroforestry Development (PRODAF) pioneered a new type of agroforestry extension in Costa Rica between 1987 and 1994. PRODAF was positioned under two national ministries (the Ministry of Agriculture and Livestock – MAG and the Ministry of Natural Resources, Energy and Mines – MINAE) and was supported by GTZ (German Technical Cooperation).

Agroforestry extension underpinned the following sectors: environmental education, promotion of training and technical assistance in agriculture and forestry, development of programmes for afforestation and agroforestry systems, and promotion/support of farmers' organisations. The approach was based on land users' participation at all stages.

The main purpose of the agroforestry extension approach was the development and promotion of sustainable production systems, which were adapted to the local biophysical and socio-economic conditions. This was to enable environmentally friendly production on steep slopes, while at the same time generating sufficient income for small and medium scale farmers in marginal areas of the Acosta-Puriscal region. In this case study, shade-grown coffee was identified to be a system that fulfilled these conditions. Another important objective was the involvement of all family members – including the younger generation.

In the first years PRODAF operated with a top-down development approach implementing technologies, designed by specialists, without consultation of land users. Local needs and experiences were not considered: as a result both adoption of shade-grown coffee was low, and maintenance was poor, despite initial incentives. The change to a participatory, bottom-up approach, with land users being represented in the steering committee (which during this period was absolutely innovative) increased acceptance among the majority of farmers towards shade-grown coffee. Participation of land users during planning and implementation was rewarded with provision of tools, seeds, fertilizer and biocides (fully financed or subsidised). The technology was evaluated on the test plots within existing coffee plantations together with the land users. PRODAF's legacy has been an institutional change in Government policy towards extension.

Location: Acosta-Puriscal, San José/Río Parrita, Costa Rica
Approach area: 400 km^2
Land use: mixed: agroforestry
Climate: humid
WOCAT database reference: QA COS02
Related technology: Shade-grown coffee, QT COS02
Compiled by: Quiros Madrigal Olman, Puriscal, Costa Rica
Date: August 2001, updated March 2004

Editors' comments: This is an example where a national programme conducted through a government agency has emerged from the success of a specific project. PRODAF's efforts regarding institutional coordination and participation of land users had a pioneer status within the country. Convinced by the positive results of the project, the national government decided to support elements of such an extension approach with its own funds.

Problem, objectives and constraints

Problem
- various different approaches of forest and agricultural technicians regarding choice and implementation of the technology – which needed harmonising
- lack of incentives for farmers to adopt technology
- lack of participatory technology development

Objectives
Promotion of appropriate management of natural resources and adoption of the shade-grown coffee agroforestry system – *café arbolado* – among small and medium scale farmers.

Constraints addressed

Major	Specification	Treatment
Technical	Lack of technical knowledge, lack of research activities/trials with SWC technologies.	Promotion of alternative production systems and SWC measures had great impact. Technology was tested on-farm. PRODAF did not focus on research activities.
Minor	**Specification**	**Treatment**
Institutional	Lack of collaboration and coordination between different institutions.	Innovative incorporation of land users in decision making, which in the meantime has become a common approach.
Financial	Lack of credit for SWC implementation.	Credit has been made available through the 'productive re-conversion programme' and other credit systems for organic/conservation production, eg Fideicomiso (see under credit).
Legal	Subdivision of land hinders adoption of SWC measures.	Not directly treated by the approach. Diverse incentive mechanisms have to be identified to promote SWC activities on small areas.

Participation and decision making

Target groups


Land users


SWC specialists/ extensionists


Politicians/ decision makers

Approach costs met by:

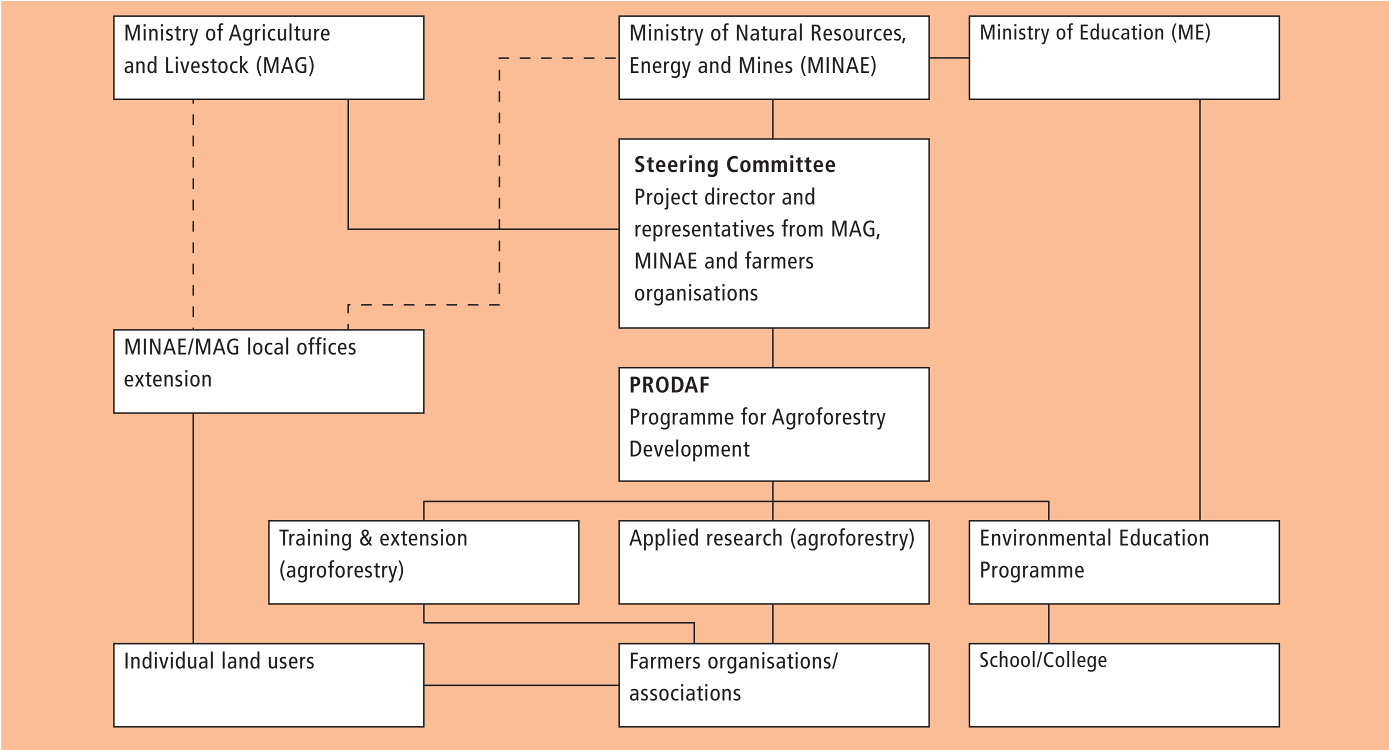
International agency: GTZ	50%
National government: MAG, MINAE	50%
	100%

Decisions on choice of the technology: Mainly made by SWC specialists with consultation of land users.
Decisions on method of implementing the technology: Mainly made by SWC specialists with consultation of land users.
Approach designed by: National and international specialists.

Community involvement

Phase	Involvement	Activities
Initiation	interactive	good participation basically through participative rural appraisal
Planning	interactive/incentives	workshops/seminar; incentives are provided for participating land users
Implementation	interactive/incentives	land users are responsible for major steps; incentives are provided for participating land users
Monitoring/evaluation	interactive	interviews/workshops
Research	interactive	on-farm

Differences in participation of men and women: Mainly men participated: women are not usually expected to carry out field activities for cultural reasons. The coffee harvest is the only activity where men and women work together in the field.



Organogram: Organisational set-up of PRODAF (Programme for Agroforestry Development)

Extension and promotion

Training: Training was provided in the form of demonstration areas, farm visits, field days, workshops, trips to projects in other regions for knowledge exchange, and public meetings. The following subjects were treated: coffee agroforestry system, fruit trees and soil conservation, silvo-pastoralism, soil conservation in general. Beside knowledge transfer, awareness raising and motivation were important aims of training. Training and extension showed good effects on land users, conservation specialists (MAG, GTZ) and extension agents. The environmental education programme was developed as a pilot project in different schools/college in the approach area by MINAE, in coordination with ME. The effectiveness of environmental education programme on students and of training on land users was excellent.
Extension: Extension carried out through extension workers was the key element of the overall approach – and the adequacy of extension for continuation was very good. Different methods were used: on-farm technical assistance; farmer-to-farmer knowledge exchange; demonstration areas and workshops. For the rating of the impact of extension on different target groups – see under 'training'.
Research: Research was included at a low to moderate level as PRODAF was not a research programme, basically in the form of on-farm trials, treating ecological and technological topics. Results were rather meagre, and the effect on the approach was thus moderate. Previous to PRODAF there was a research project conducted by CATIE (Tropical Agricultural Research and Higher Education Centre) in the approach area, but results were not broadly disseminated.
Importance of land use rights: Land fragmentation leads to very small areas per household. This hinders implementation of SWC activities. Land users do not have the resources to invest in initial inputs and activities.

Incentives

Labour: Labour was basically voluntary, although the provision of tools by the project worked as an encouragement.
Inputs: PRODAF provided all seedlings for the tree components in the *café arbolado* system, free of charge. The farmers only needed to present themselves to qualify for the coffee plants. During the implementation phase hand tools, fertilizer and transport costs were partly subsidised by PRODAF.
Credit: Credit was provided through the 'productive re-conversion programme' to support small-scale organic production and soil conservation. Interest rate was lower than the market rate. After PRODAF a larger (national) credit programme to promote agroforestry systems was launched in the approach area, under MAG and National Production Council (CNP). *Fideicomiso* is another national financing programme based on a contract between a bank and development institutions.
Support of local institutions: Moderate support: financial support, training, equipment and construction of buildings.
Long-term impact of incentives: Initial incentives were important to compensate the costs of technology implementation. In combination with the provided training and environmental education, it is assumed that the impact will be positive in the long term.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	ad hoc measurements of yields
Socio-cultural	regular observations of family size
Economic/production	regular measurements of yields and produce marketed
No. of land users involved	regular measurements of land users involved in organisation

Impacts of the approach

Changes as result of monitoring and evaluation: The approach changed completely after evaluation of the first phase, from an initial top down methodology with low technology adoption by land users, to a more participative approach heeding land users' opinions and needs, and improving communication between technicians and land users. This was helped by the development of educational materials.
Improved soil and water management: There was substantial improvement of soil and water management through application of the agroforestry systems.
Adoption of the approach by other projects/land users: Some projects in the region as well as in other parts of the country adopted the approach. Various SWC extension programmes have adopted the extension methods promoted by PRODAF, based on the principles of land users participation. In the Ministry of Agriculture and Livestock it has been taken as a basic principle in the National Programme of Agricultural Extension.
Sustainability: While the approach has been institutionalised (see above) and a national credit programme set up promoting shade-grown coffee and silvo-pastoral systems (see section on credit), continuation of field production activities is uncertain. Farmers' motivation to apply SWC technologies was raised with the Environmental Education Programme, but if market prices for coffee decrease or show high variability, farmers lose the motivation to maintain their plantations.

Concluding statements

Strengths and ➜ **how to sustain/improve**	**Weaknesses** and ➜ **how to overcome**
Institutionalisation of the basic participatory extension approach within the Ministry of Agriculture and Livestock.	No economic security guaranteed in the long term because of price fluctuations ➜ Provide a system of incentives, eg lower taxes for those who apply SWC technologies.
Initial top-down approach replaced by participation with land users ➜ Continue to spread information about the effectiveness of this change in attitude, and the need for responsiveness in projects and programmes.	
Training of land users (knowledge of soil degradation processes and soil and water conservation) ➜ Collaboration with farmers organisations, NGOs and agricultural extension services. Better dissemination of research results.	
Environmental education in schools ➜ Continue support through the Ministry of Education.	

Key reference(s): PRODAF (1992) *Informe de evaluación de las parcelas agroforestales establecidas por PRODAF,* Periodo 88–91, Puriscal, Costa Rica ■ Quiros O (2000) *Nachhaltigkeit von landwirtschaftlichen Produktionsverfahren in bäuerlichen Familienbetrieben in Costa Rica.* Vauk-Kiel KG: *series of: Sozialökonimische Schriften zur Ruralen Entwicklung,* Vol. 20
Contact person(s): Quiros Madrigal Olman, *Ministerio de Agricultura y Ganadería,* Santiago de Puriscal, 85-6000 Puriscal, Costa Rica; phone ++ 506 416 87 35, fax ++ 506 416 87 38; ojquiros@yahoo.com

left: Narrow terraces, each with a water retention ditch, for fruit trees (note grape vine in the foreground). (Bettina Wolfgramm)
right: Agroforestry plot surrounded by overgrazed and heavily, degraded grazing land; note also fenced plot with grass plot for hay making above the plot. (Hanspeter Liniger)

Conversion of grazing land to fruit and fodder plots

Tajikistan – Ивазнамудани замини чарогох ба богот

Fencing part of an overgrazed hillside, combined with terracing, manuring and supplementary irrigation for grape, fruit and grass production.

In the Varzob valley of Tajikistan, slopes of around 30% are used communally, and are heavily overgrazed. This has led to a reduction in vegetation cover, to soil compaction and to severe sheet and rill erosion. In 1982, one innovative land user began to set up half a hectare vineyard/fruit plot with intensive grass/fodder production for cut-and-carry and separate section above for hay making – through his own initiative. By the application of various conservation measures, within five years an area exposed to severe water erosion was converted into sustainable use. Fodder and fruits are now flourishing and the natural resources of soil and water are conserved effectively.

The start of the process was fencing of the plot to keep out animals. Scrap metal and other materials from a machinery depot were used to build a 1.5 m high fence. To harvest and hold runoff water from the hillside for grapes and fruit trees, narrow backsloping terraces were constructed, each with a water retention ditch along the contour. During the initial phase, the terraces did not harvest enough water for establishment of the seedlings. So water for supplementary irrigation was carried to the plot by donkeys in old inner tubes from car tyres. Manure is applied to the plot to improve soil fertility. The manure is collected on the high pastures where the herders graze their animals during summer. The total amount of manure applied to the plot so far amounts to about 3 t/ha over 20 years.

For the innovator, his most valuable fruits are grapes, followed by apricots, almonds and plums. He has also successfully grown mulberry, pomegranate and cherry trees. Not all the seedlings survive: the farmer considers a 40% survival rate of grape vines to be reasonable. The harvest of fruit is mainly used for home consumption. However, in a good year the table grapes and apricots are sold on the market. The hay harvest, from naturally regenerated grasses and fodder plants between the fruits amounts, on average, to 0.2 t/ha/year. The pruned branches from the vines are collected and used as firewood.

The establishment of such a plot is very demanding in terms of manpower. However within 5–6 years the system becomes self-sustaining and the productivity of the land is improved several times over. Following this positive experience, other households in the area have adopted the technology spontaneously, and today about 15 ha of degraded grazing land in the Varzob valley have been converted into productive fruit gardens.

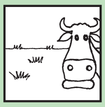
Location: Khagatai, Varzob, Tajikistan
Technology area: 0.15 km^2
SWC measure: management, structural, vegetative and agronomic
Land use: grazing land (before), mixed: agrosilvopastoral (after)
Climate: subhumid
WOCAT database reference: QT TAJ04
Related approach: Farmer innovation and self-help group, QA TAJ04
Compiled by: Ergashev M, Nekushoeva G and Wolfgramm B, Soil Science Institute, Dushanbe, Tajikistan
Date: June 2004, updated October 2004

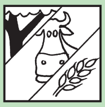
Editors' comments: Where open access communal grazing leads to land degradation, individuals sometimes enclose land for productive purposes. This positive example is from Tajikistan where the initiative began during the period of the soviet regime. Similar initiatives can be seen in western Iran. However, if a significant number of land users follow suit, there will be a reduction in the amount of land available for common use.

Classification

Land use problems
- shortage of cultivable land on the gentle slopes next to the rivers
- low yield of natural pastures due to overgrazing
- heavy erosion taking place near residential areas

Land use


extensive grazing (before)

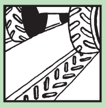

agro-silvopastoral: fruit trees/vines (irrig.), cut-and-carry (after)

Climate


subhumid

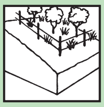
Degradation

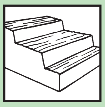

water erosion: loss of topsoil

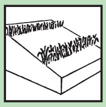

physical: compaction

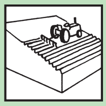

vegetation: reduced cover

SWC measures


management: land use change from grazing land to tree crops


structural: bench terraces (backward sloping)


vegetative: fruit trees/vines aligned


agronomic: manuring

Technical function/impact

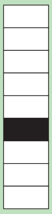
main:
- improvement of ground cover
- retain/trap dispersed runoff
- increase in organic matter
- increase in soil fertility

secondary:
- reduction of slope angle
- water harvesting
- retain/trap concentrated runoff (prevention of gully erosion)
- reduction of wind speed

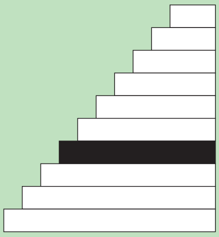
Environment

Natural environment

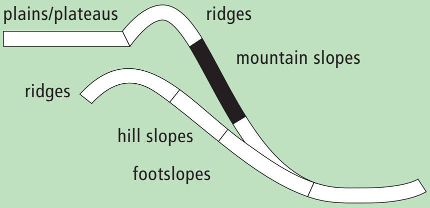
Average annual rainfall (mm)



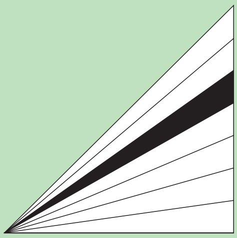
Altitude (m a.s.l.)



Landform



Slope (%)



Soil depth (cm)

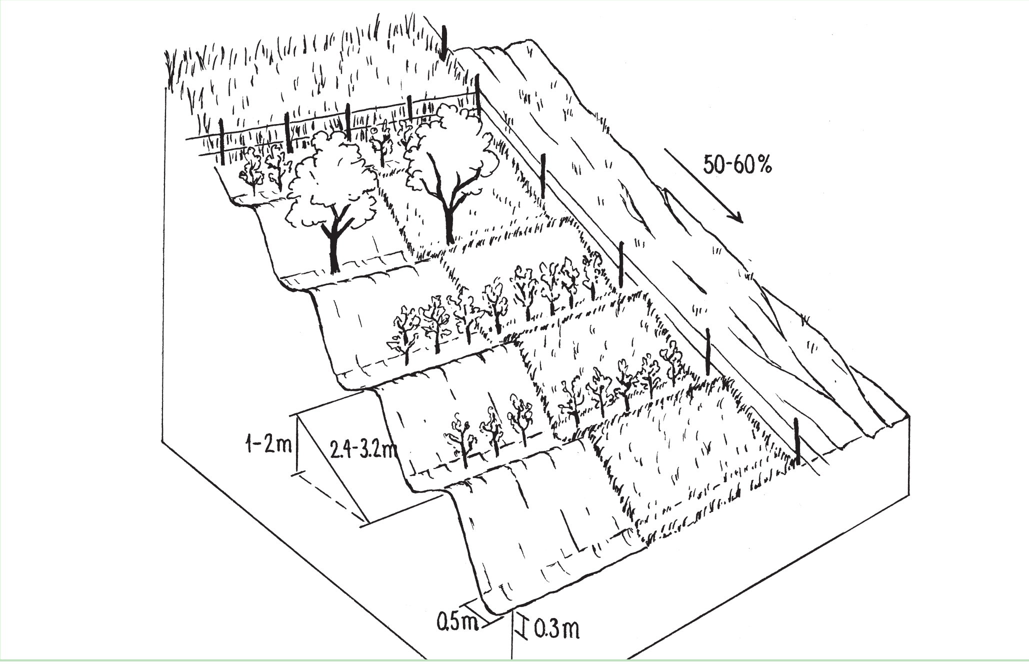
NB: soil properties before SWC

Growing season: 210 days (March to October)
Soil fertility: mainly low, partly medium
Soil texture: medium (loam)
Surface stoniness: no loose stone
Topsoil organic matter: low (<1%)
Soil drainage: good
Soil erodibility: high (loess soils)

Human environment

Mixed land per household (ha)

Land use rights: mostly communal, partly individual
Land ownership: in soviet times the state; today village farmers may be allowed to cultivate land privately, though the official rights are with the village authorities (communal ownership); most land is used communally
Market orientation: mixed (subsistence and commercial): mainly self-supply, in good years a part of the apricot harvest is sold on the market
Level of technical knowledge required: land user: partly moderate (construction of terraces) and partly low (simple knowledge of agronomy, manure application, harvesting etc)
Importance of off-farm income: 50% of the family's total income comes from three sons working in Moscow



Technical drawing
The fenced-off agroforestry system comprising fruit trees and cereals grown on a steep hillside. Terracing is crucial for water conservation. Grass cover (right) is established for fodder production and simultaneous soil conservation. Note the adjacent plot for haymaking (above) and degraded rangeland outside the protected area (right).

Implementation activities, inputs and costs

Establishment activities

1. Fencing of an area of 0.5 ha using waste material from a machinery depot.
2. Construction of backward sloping bench terraces.
3. Planting of vines and fruit tree seedlings (apricot, plumes, almonds) along the terraces.
4. Irrigation (old inner tubes filled with water carried to the plot by donkeys) during the first 5–6 years after planting. In spring: every 3 weeks. In summer: 5 litres of water per tree, per week.
5. Manuring: applied at first to the newly planted vines/trees only, due to restricted availability. During the second half of the establishment phase also applied elsewhere within the plot.

Duration of establishment: 5–6 years

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour (around 300 person days)	600	100%
Equipment		
- Machines (car for transportation of manure)	50	100%
- Animals for transportation (270 hours)	200	100%
- Tools (shovels, hoes, old inner tubes from car tires)	0	
Materials		
- Water	0	
- Scrap metal	0	
Agricultural		
- Fruit tree seedlings (local, 40)	40	100%
- Grape vines (local, 1,500)	1,500	100%
- Manure (1,500 kg)	300	100%
TOTAL	**2,690**	**100%**

Maintenance/recurrent activities

1. Repairs to the fence are carried out every year.
2. Vines and trees that fail are replaced.
3. Irrigation of new seedlings.
4. Grapes and trees pruned every year.
5. Harvesting of fruits and fodder: transport of the yield to the house by donkey.
6. Manuring, when replacing grapes or trees that had died: manure is transported from summer pastures to the village by cars and to the plot by donkeys (every year).

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Labour (390 person days)	180	100%
Equipment		
- Tools (hoes, scissors for pruning)	0	
- Animals for transportation (270 hours)	200	100%
Materials		
- Water	0	
Agricultural		
- Seedlings (around 20)	20	100%
- Vines (local, 150)	150	100%
- Manure (100 kg)	20	100%
TOTAL	**570**	**100%**

Remarks: Labour cost per day is US$ 2. The fence constructed by the farmer was free because he utilised scrap from a machinery depot. Note that the total length of fencing is relatively less for a larger plot. In the villages there is almost no money changes hands: there is a barter system between the farmers. Even salaries are often paid in terms of fruits, wood or free rent of land.

Assessment

Acceptance/adoption
- Out of 250 households 5 (2%) have currently fenced plots for fruit production.
- Adoption was spontaneous in all cases and there are signs of further spread.

Benefits/costs according to land user

Benefits compared with costs	short-term:	long-term:
establishment	negative	positive
maintenance/recurrent	negative	very positive

Impacts of the technology

Production and socio-economic benefits
- +++ increase in fruit production
- ++ increase in production of high quality fodder
- + wood production increase
- + farm income increase (depending on the rainfall during the year)

Socio-cultural benefits
- +++ improved knowledge SWC/erosion
- + community institution strengthening (terrace construction requires collaboration of relatives and friends)

Ecological benefits
- +++ soil cover improvement
- +++ increase in soil moisture
- +++ efficiency of excess water drainage
- +++ increase in soil fertility
- +++ soil loss reduction
- ++ biodiversity enhancement

Off-site benefits
- ++ reduced transported sediments
- + reduced flooding of the road at the bottom of the slope (conserved area is too small to have significant impact)

Production and socio-economic disadvantages
- −−− labour constraints: high labour input needed for establishment and recurrent irrigation
- − increased input constraint (for manure application)

Socio-cultural disadvantages
- −− conflicts: in the beginning conflicts due to jealousy, loss of community grazing land and fear of landslides caused by water retention on sloping loess areas.

Ecological disadvantages
- −− poorly maintained terraces may lead to increased erosion

Off-site disadvantages
- − increased risk of landslides due to water harvesting

Concluding statements

Strengths and ➜ how to sustain/improve

Rehabilitation of degraded areas: reduced soil erosion and increased productivity ➜ Complement manure inputs by other fertilizers.

Production increase: good fruit yields ➜ Introduce low input demanding and fast producing tree species and varieties.

Diversification: different kinds of fruit trees growing on the plot ➜ Other trees (nuts for example) and annual crops such as wheat might also be suitable for this area.

Income generation.

Weaknesses and ➜ how to overcome

Bringing water for supplementary irrigation to the orchard is very labour intensive ➜ An irrigation supply system could be installed (irrigation channels, water tank). But so far this is too expensive, and it is questionable whether irrigation could be installed and maintained sustainably on these steep slopes with loess deposits.

Not all tree species can grow in these dry conditions (for example apple trees will not survive without regular irrigation or watering) ➜ Additional irrigation water required (see above).

Difficulty in establishment of the young vines in the well developed grass ➜ Remove or cut down grass and herbaceous plants around the vines at least until they have well established.

Generally high manual labour input ➜ Difficult to reduce labour inputs.

Key reference(s): none.

Contact person(s): Sharif Aliev family, Khagatai Village, Rayon of Varzob, Tajikistan ■ Murod Ergashev, CAMP – Central Asian Mountain Partnership Program, 12, Istrafshan Str. Apt 5, 734025 Dushanbe, Tajikistan; phone: ++992 372 210227; murod@swiss.tojikiston.com


left: The fenced plot 20 years after establishment: degraded grazing land on the steep and degraded slopes of Varzob Valley has been turned in a productive area. (Hanspeter Liniger)
right: The innovative farmer, Sharif Aliev, depended on the support of relatives and friends to establish the new land use system. (Gulniso Nekushoeva)

Farmer innovation and self-help group

Tajikistan – Шахсияти ихтироъкор ва Хашар

Overcoming administrative and technical problems, an innovative land user, assisted by a self-help group, has established a fruit garden within degraded communal grazing land.

Although in the 1980s the soviet government supported the establishment of private gardens in specified areas, the lack of irrigation water and suitable land often restricted this process. That was the case for Khagatai village, situated on the narrow valley floor of the Varzob River, below steep loess slopes. This marginal area is used for grazing and shows severe signs of water erosion; the hillsides are considered to be of little value.

In the early 1980s, widespread unemployment evidently had the effect of stimulating people to use their own initiative. In 1982, one innovative farmer started to fence-off an area of half a hectare to establish a private fruit garden on the degraded grazing land. Some say that the fencing of plots for private fruit and hay production is a traditional practice – abandoned after the 1950s – but taken up again recently to re-establish rights to individual plots. The practice is widespread in the higher villages of Varzob, where the farmer noted it and decided to set up his own plot. When it came to practical implementation, despite the land user having five sons, the labour-intensive terracing was only completed thanks to voluntary work of relatives and friends, a tradition locally termed *hashar.*

At first, when his initiative began to take shape – on land officially owned by a state farm – nobody reacted. However, the change in land management quickly showed positive productive results, and it may have been through jealousy that the people of Khagatai village then reported the case to the authorities. But the watering of the garden on the unstable loess slope in the immediate vicinity of the village, and the consequent risk of landslides, was put forward as the reason for the complaint. The authorities opened an investigation and a number of newspaper articles appeared. Since independent decision taking was not common in the soviet states, and furthermore rapid degradation of newly irrigated lands on the loess deposits was a burning issue, the case of this fruit garden attracted a lot of attention. However, convinced by the improved state of vegetation on the plot, the authorities finally allowed the farmer to continue.

In 1993 the prohibition on private cultivation of land was lifted in order to reduce problems of food shortage caused during the civil war that followed independence. It was during this time that four other land users from Khagatai village spontaneously began to imitate the practice.

Location: Khagatai, Varzob, Tajikistan
Approach area: 0.15 km^2
Land use: mixed: agro-silvopastoral (after)
Climate: subhumid
WOCAT database reference: QA TAJ04
Related technology: Conversion of grazing land to fruit and fodder plots, QT TAJ04
Compiled by: Ergashev M, Nekushoeva G and Wolfgramm B, Soil Science Institute, Dushanbe, Tajikistan
Date: July 2004, updated October 2004

Editors' comments: It was very unusual during the soviet times for a villager to take the initiative to establish a private plot on state land. However in this example, the success in establishing a vineyard on an overgrazed hill convinced the administration of its worth. Other land users have now followed this approach.

Problem, objectives and constraints

Problem

- the land in question is part of a communal grazing area and property rights are officially with Khagatai village (though in soviet times with a state farm)
- uncontrolled grazing on communal lands has resulted in overgrazing and thus to progressive water erosion on the steep loess deposits
- no attention was paid by the local authorities to soil and water conservation measures in areas considered of low agricultural potential

Objectives

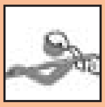
- to establish an orchard with grape vines, fruit trees and fodder crops for private use

Constraints addressed

Major	Specification	Treatment
Social/cultural/religious	Jealousy of other village members, who didn't like a land user fencing-off a plot in communal grazing land.	Others became convinced after the change in land use. Newspaper articles on the case also helped shape public opinion.
Institutional	Private initiatives on state land were not intended under the soviet system.	Activities tended to start on marginal land that was of little agronomic interest to state farms.
Financial	All inputs had to be provided by the land user himself.	Creative ways were developed to provide material for fencing, for transportation of irrigation water and for access to manure.
Technical	For the establishment of the orchard irrigation water was needed. This had to be brought 200 m up a steep slope.	Water in old inner tubes was transported to the orchard by donkey.
Availability of labour	Construction of terraces for tree planting is very labour intensive.	Voluntary work of relatives and friends: an approach locally called *hashar*.
Minor	**Specification**	**Treatment**
Legal	No individual property rights.	In soviet times the land belonged to a state farm. Today the land belongs to Khagatai village: efforts to achieve official individual ownership have not succeeded.

Participation and decision making

Target groups



Land users

Approach costs met by:

Land user, private	100%
	100%

Decisions on choice of the technology: Made by land user alone (bottom up).
Decisions on method of implementing the technology: Made by land user alone (bottom up).
Approach designed by: Land user.

Community involvement

Phase	Involvement	Activities
Initiation	self-mobilisation	the initiative was initiated by an individual land user
Planning	self-mobilisation	the planning was done step by step: problems were addressed as they arose
Implementation	self-mobilisation	the project was implemented by the individual land user, relatives and neighbours participated voluntarily in terrace construction
Monitoring/evaluation	self-mobilisation	the project is monitored and evaluated by the individual land user
Research	interactive	post-implementation documentation (participatory)

Differences in participation of men and women: Mainly men participated: women are not usually expected to carry out field activities for cultural reasons. The coffee harvest is the only activity where men and women work together in the field.

left: The son of the innovator (centre, without hat) who manages the conserved area, discussing technical impact with researchers from the NCCR North-South Programme (see research). (Hanspeter Liniger)
right: Cutting grass in the fenced plot: land use was changed from open access grazing to cut and carry. (Hanspeter Liniger)

Extension and promotion

Training: The land user's own knowledge proved quite adequate when he started to plan and implement the SWC measures, despite the fact that he had not received formal training.
Extension: 'Extension' of the technology happened through observation and farmer-to-farmer exchange of ideas.
Research: There had been no research until the identification and documentation of this initiative through a Tajik-Swiss project under the framework of the National Centre of Competence in Research (NCCR) North-South (coordinated by the Centre for Development and Environment, Switzerland).
Importance of land use rights: In soviet times the land was owned by a state farm, today it belongs to Khagatai village and is used as communal grazing land. When the fruit garden was first established an investigation resulted in approval of the private land use on these marginal lands. Today, despite efforts to get an owner's certificate, the official ownership for the land where the fruit garden is situated is with Khagatai village. Under such circumstances the land user is not willing to invest any more in the expansion of area, because of this insecurity.

Incentives

Labour: All labour by land users was voluntary.
Inputs: All the inputs were fully financed by the land user himself. This includes hand tools, fruit tree seedlings, vines, manure, supplementary irrigation, water transport by donkey and by car.
Credit: No credit was provided.
Support to local institutions: None.
Long-term impact of incentives: No incentives were available.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	ad hoc observations by the land user concerning the growth of seedlings
Economic/production	ad hoc comparison of yields between different years
No. of land users involved	ad hoc observations

Impacts of the approach

Changes as result of monitoring and evaluation: There were a few changes due to the observations made by the land user: he started to apply supplementary irrigation to the tree seedlings, as well as to apply manure each year.
Improved soil and water management: There has been a significant, though localised, improvement in soil and water management.
Adoption of the approach by other projects/land users: Other land users from Khagatai village have adopted the system on the same hillside. They started fencing-off plots in the 1990s during the civil war. At that time many people were unemployed, and labour was therefore available. Furthermore there was a shortage in food supplies and people relied on the production from the land.
Sustainability: Because this approach is based on local initiative there is no reason why it should not endure. The insecure land use rights are the only potential risk to the continuation of the activities.

Concluding statements

Strengths and ➜ how to sustain/improve	**Weaknesses** and ➜ how to overcome
Bottom-up approach: independent decision making by the individual land user based on dynamic and flexible response ➜ Give property rights to land users to motivate further investments in soil and water conservation/production.	Since it is an initiative of an individual land user, the SWC technology has not been documented so far, nor evaluated, and lessons learned have not been spread among the land users ➜ Documentation and spreading of lessons learned.
Rehabilitation of marginal land for production and generation of additional income ➜ Give property rights to land users to motivate further investments in soil and water conservation/production.	Only families with sufficient labour resources can establish such a garden by themselves ➜ Incentives from the state or other organisations are needed.
	Not all farmers can apply this technology since it is location specific ➜ Identify if fodder production (cut-and-carry) would be more attractive than open grazing; allocate land to the farmers.
	Current systems of land ownership (today the land belongs to Khagatai village) ➜ Provide land ownership to the farmers.

Key reference(s): none.
Contact person(s): Sharif Aliev family, Khagatai Village, Rayon of Varzob, Tajikistan ▪ Murod Ergashev, CAMP – Central Asian Mountain Partnership Program, 12, Istrafshan Str. Apt 5, 734025 Dushanbe, Tajikistan; phone: ++992 372 210227; murod@swiss.tojikiston.com


left and right: Typical examples of apple trees intercropped with wheat. Alignment of the trees is often a compromise between wind direction, slope and shape of plot. (Hanspeter Liniger)

Orchard-based agroforestry

Tajikistan – Хамбастагии богот ва зироат

An agroforestry system where legumes and cereals are planted in fruit orchards, giving simultaneous production and conservation benefits.

In Faizabad region, Tajikistan, an area which is characterised by hilly topography and deep but highly erodible loess soils, farmers traditionally cultivated beans and wheat in combination with fruit trees. This was a rather unsystematic agroforestry system, and during soviet times (in the 1980s) fruit production was intensified. Pure-stand orchards were established: the land was leveled and on slopes exceeding 20% terraces were constructed mechanically. The density of trees was increased, and the little space remaining between was used for hay production. Annual cropping was stopped.

After the soviet era, farmers reduced the number of trees, allowing room for intercropping. They also established new orchards according to this same pattern. The density of apples was reduced by expanding the spacing from approx 5 m to 10 m between rows and from 2 m to 4 m within rows. Along each row of trees a 2–3 m strip of grass was left to grow. Layout of fruit tree lines is a compromise between being along the contour and against the prevailing wind. After harvesting of fruit, between August and October, farmers sow their annual crops. Those who farm leased land merely intercrop wheat, whereas the few farmers who own their land, rotate crops with two years of wheat followed by one of legumes (beans or lucerne). Crops are grown both for home consumption and sale.

This agroforestry system provides protection against strong winds, heavy rains and flooding. Soil erosion (by water) has been reduced due to improved soil cover by the intercrop, and through leaf litter, which is left to decompose on the ground. Furthermore, after harvesting, about three quarters of the crop residues are left on the field as mulch. The remainder is used as fodder. Soil organic matter within the current agroforestry system is considerably higher than in the surrounding grazing areas. Soil fertility has improved also: beans can fix 60–80 kg/ha/year of nitrogen. Compared with other crops, wheat provides the best erosion protection. Since the lateral rooting system of the apple trees reaches only 1–1.5 m from the trunk, competition for nutrients is not a major problem. Neither is there a problem with shading, since during the crop establishment period the trees have dropped their leaves. In order to increase production, farmers plan to apply supplementary irrigation where possible.

Location: Faizabad, Tajikistan
Technology area: 45 km^2
SWC measure: vegetative, agronomic and structural
Land use: cropland: orchards (before), mixed: agroforestry (after)
Climate: semi-arid
WOCAT database reference: QT TAJ03
Related approach: Transition from centralised regime to local initiative, QA TAJ03
Author: Sanginov Sanginboy and Bettina Wolfgramm, Soil Science Institute,Dushanbe, Tajikistan
Date: January 2004, updated December 2004

Editors' comments: The major advantage of agroforestry lies in the functional integration of different resources and farming techniques. In this way the productivity of the farm system can be increased, and soil and water resources simultaneously conserved. As fruit production is very important for income generation in Tajikistan, this agroforestry system is already popular and has potential for wider application.

Classification

Land use problems

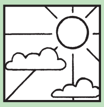
Most of the rains fall in late autumn and early spring, and the rains coincide with very strong winds. The topsoil is therefore exposed to erosion during this period if left uncovered, and without a windbreak. A particular problem during the soviet period was that the intensive orchard system meant annual food crops were left out of the production system: soil cover was reduced and there was less food.

Land use

tree crops: apple orchards (before)

agroforestry: apple trees and annual crops (wheat/beans)

Climate



semi-arid

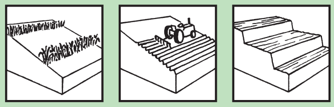
Degradation

water erosion: gully, loss of topsoil

wind erosion

chemical: fertility decline

SWC measures



vegetative: trees as wind breaks, grass strips

agronomic: intercropping, crop rotation, mulching

structural: terraces

Technical function/impact

main:
- improvement of ground cover
- reduction in wind speed
- improvement of soil fertility (with crop rotation including beans and lucerne)

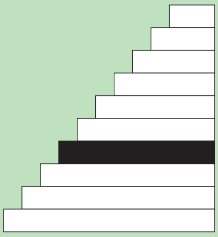
secondary:
- reduction of slope angle
- water harvesting
- retain/trap concentrated runoff (prevention of gully erosion)
- reduction of wind speed

Environment

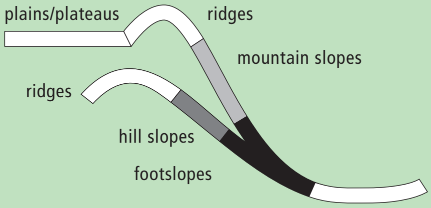
Natural environment

Average annual rainfall (mm)

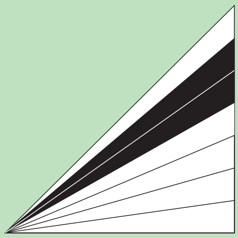
Altitude (m a.s.l.)



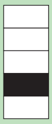
Landform



Slope (%)



Soil depth (cm)



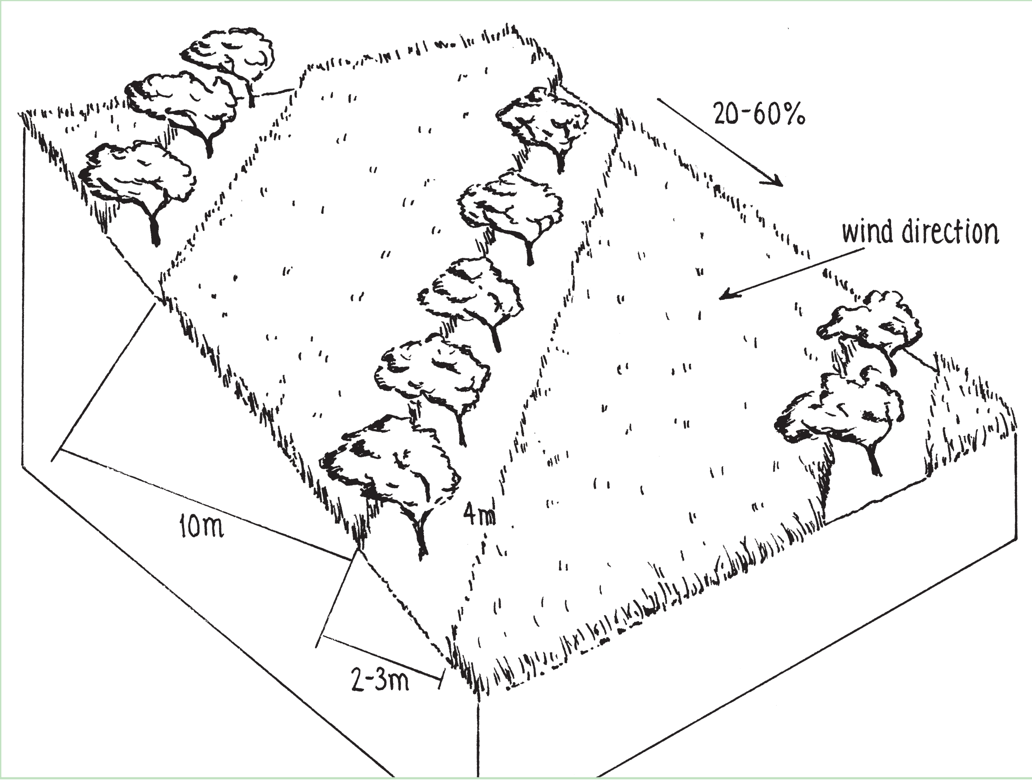
NB: soil properties before SWC

Growing season: 270 days for winter wheat (October/November to June/July)
Soil fertility: mostly low (eroded loess soils, exposure of the calcareous layers)
Soil texture: medium (loam)
Surface stoniness: some loose stone
Topsoil organic matter: low (<1%)
Soil drainage: good
Soil erodibility: very high

Human environment

Mixed land per household (ha)

Land use rights: mostly leased
Land ownership: state
Market orientation: mixed (subsistence and commercial)
Level of technical knowledge required: field staff/extension worker: moderate, land user: moderate
Importance of off-farm income: >50% of all income: trade and business; young men often migrate to Russia (seasonally or for several years) to search for jobs



Technical drawing
Fruit trees intercropped with wheat (or beans): note the fruit trees are aligned on a 'compromise' between the direction of the prevailing wind and the slope.

Implementation activities, inputs and costs

Establishment activities
1. Levelling of steep land into terraces with graders
2. Planting of fruit orchards
3. Thinning: doubling the spacing between trees (by farmers, after soviet era)

Note: these costs are not considered in the table

Establishment of new intercropped plots by farmers
1. Applying organic manure with machinery for crops and trees (November to March).
2. Ploughing with tractor to depth of 25–30 cm for annual crops (November to March).
3. Disc ploughing and harrowing with tractor (March).
4. Planting of fruit tree saplings by hand (March, April).
5. Chemical fertilizer application to crops (once during season).
6. Pest management with chemicals (two-three times where possible/ affordable).

Duration of establishment: not specified

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour (around 20 person days)	60	100%
Equipment		
- Machines (30 hours)	120	100%
- Tools	10	100%
Agricultural		
- Fruit tree saplings (250)	250	100%
- Fertilizers (250 kg NPK)	50	100%
- Pesticides (6 kg)	30	100%
- Manure (15–20 tons)	30	100%
TOTAL	**550**	**100%**

Maintenance/recurrent activities
1. Ploughing of land and planting of crops.
2. Fertilisation and pest control.
3. Harvesting: wheat is the only crop that is harvested mechanically if tractors and fuel are available.
4. Mulching of trees.
5. Pest control for trees, three times a year (before and after flowering and after harvesting).
6. Pruning of trees.

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Labour (around 15 person days)	45	100%
Equipment		
- Animal traction (10 hours)	10	100%
- Tools	10	100%
Agricultural		
- Seeds (250 kg)	30	100%
- Fertilizers (250 kg)	50	100%
- Compost/manure (1 tons)	10	100%
- Pesticides (1 kg)	5	100%
Pruning	40	100%
Mulching	10	100%
TOTAL	**210**	**100%**

Remarks: Cost calculation refers to farmers who established new agroforestry plots (without receiving any incentives). These are farmers who have leased land from state farms. However, conversion of soviet orchards is more common than the establishment of new agroforestry plots (information on costs not available).

Assessment

Acceptance/adoption

Adoption rate is high: 3,500 households in the region, who leased the orchards, have converted them without any incentives. Marginal farmers received incentive support from NGOs (Care International, German Agro Action) or WFP (the UN's World Food Programme under their 'Food for Work' Programme).

Benefits/costs according to land user

Benefits compared with costs	short-term:	long-term:
establishment	positive	very positive
maintenance/recurrent	very positive	very positive

Impacts of the technology

Production and socio-economic benefits

- +++ crop yield increase
- +++ fodder production/quality increase
- ++ wood production increase
- ++ farm income increase

Production and socio-economic disadvantages

- − trees hinder farm operations
- − difficult to apply pesticides using machinery; furthermore pesticides are very expensive
- − pruning is important, and farmers new to the system don't always have the skills required

Socio-cultural benefits

- \+ community institution strengthening
- \+ improved knowledge SWC/erosion

Socio-cultural disadvantages

- − orchards managed by state farms are often not well looked after

Ecological benefits

- +++ soil cover improvement
- +++ increase in soil organic matter
- ++ increase in soil fertility
- ++ soil loss reduction
- ++ biodiversity enhancement
- ++ reduction of wind velocity
- ++ increase water use efficiency
- ++ increase nutrient use efficiency
- \+ increase in soil moisture
- \+ efficiency of excess water drainage

Ecological disadvantages

- − up and down slope cultivation for supplementary irrigation promotes sheet and rill erosion

Off-site benefits

- ++ reduced downstream flooding
- ++ increased stream flow in dry season
- ++ reduced river pollution
- ++ reduced transported sediments
- \+ reduced downstream siltation

Off-site disadvantages

none

Concluding statements

Strengths and ➜ how to sustain/improve

Easy to convert orchards ➜ Land reform from state to private ownership would assist the process and strengthen farmers' associations.

Helps provide employment (mainly self-employment, partly employment of additional labourers) and increase self-sufficiency. With the cultivation of wheat, some farmers can solve their food problems and do not need an off-farm income.

Improvement of soil fertility and soil organic matter content ➜ Use all the crop residue and leaves of trees as cover (mulch).

Considerable reduction of soil erosion ➜ Adopt cover crop and rotation with other leguminous and minimum tillage system.

Wider spacing between the rows of trees (to 10 m) is best for the agroforestry system to function well ➜ Remaining orchards with the original (soviet) spacing of 5 m between the rows should be thinned.

Weaknesses and ➜ how to overcome

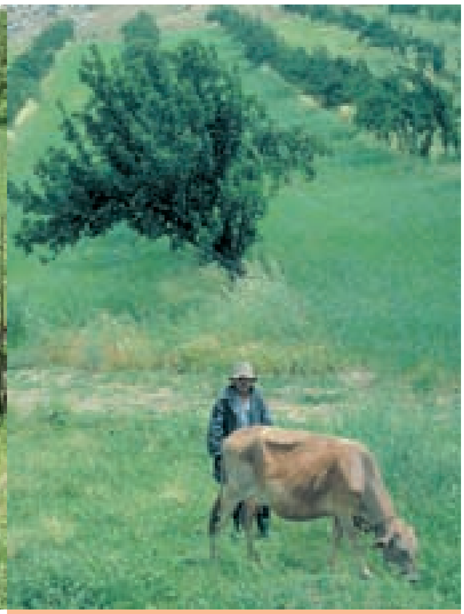
The irrigation system established during soviet times required high maintenance inputs due to siltation of the canals. During the period of the civil war systems ceased to function, the canals filled up with sediments and finally overflowed during rain storms causing gully formation ➜ Control of water flow within the orchard using cutoff drains and drainage ditches.

Lines of trees which are planted up and down the slope to provide wind protection are prone to water erosion ➜ Compromise in layout design (see description).

Orchards managed by state farms are often not well looked after ➜ leasing of land and awarding landholder certificates leads to improved orchard management.

Key reference(s): none

Contact person(s): Sanginov SR, Ergashev M, Akramov U, Mahamadkarimova S, Boturov U, Soil Science Institute, Rudaki aven 21A, Dushanbe, Tajikistan; soil2004@mail.ru; phone ++992-372-272979, fax ++992-372-213207



left: Students documenting the technology; the farmer (brown hat) and a scientist from the Soils Institute (green hat) are the contributing specialists. (Peter Niederer)
right: The area around the orchards is used for grazing; note wind-swept trees in the background. (Hanspeter Liniger)

Transition from centralised regime to local initiative

Tajikistan – Ташаббуси дехконон ва хокимияти мутлак

A land use system established during the authoritarian regime of the Soviet Union is being adapted to farmers' needs through their own initiative.

This case study compares two approaches which both contributed to the development of today's orchard-based agroforestry system: (1) Soviet approach: the previous state-run dictatorial system of the soviet times and (2) Farmers' initiative: the current bottom-up approach.

Farmers from the hilly Faizabad region with its deep and highly erodible loess soils had traditionally combined the cultivation of beans and wheat with fruit trees. In the 1980s the soviet administration decided to intensify apple production in this area and to establish orchards on a large scale, making use of the ideal natural environment. The system introduced comprised densely planted pure-stand orchards, mechanically constructed terraces (where the slopes required this), and an irrigation system. Establishment was conducted through a top-down/authoritarian approach, and all inputs for implementation and maintenance were provided by the state. Farmers worked as employees on the state farms and received cash wages.

After the collapse of the Soviet Union and the start of the civil war, Tajikistan suffered from acute food shortages. In 1993, the Tajik government lifted the prohibition on planting wheat in rainfed areas. Farmers leasing the land of the former state farms began to revert to intercropping annual crops – mainly wheat and beans – between thinned rows of apple trees. This was both for household use and for sale on the market. The initiative came from the farmers, and reflected the traditional system of production. However the pumping station and irrigation system have not been working for the last 10 years and therefore supplementary irrigation has not been available.

In contrast to former times, decision-making, management activities, and provision of inputs/finance are all carried out by the land users themselves. In some cases, marginal farmers received incentive support from NGOs or from the World Food Programme. Systematic assistance from extension services, financial support to purchase pesticides or fertilizers, and investment to restore the irrigation system would all help to improve the agroforestry system and thus raise yields.

Location: Faizabad, Tajikistan
Approach area: 45 km^2
Land use: mixed: agroforestry
Climate: subhumid
WOCAT database reference: QA TAJ03
Related technology: Orchard-based agroforestry, QT TAJ03
Compiled by: Sanginboy Sanginov, Soil Science Institute, Dushanbe, Tajikistan
Date: May 2004, updated December 2005

Editors' comments: This case illustrates the challenges in the transition from state-run large-scale farming to individual management of smaller units. In this case, soviet Tajikistan had established pure-stand orchards. However, in response to acute food shortage during the civil war, farmers started to intercrop wheat and beans in their orchards: a better all-round production/conservation system.

Problem, objectives and constraints

Problem

- Soviet times: the original problems addressed by the authorities during the soviet era was how to increase agricultural production in a purely technocratic way, without consideration of the rural population.
- Post-soviet period: in 1993, when the soviet era ended and the prohibition on cultivation of wheat was lifted, the underlying problem was a shortage of food – and especially of wheat.

Objectives

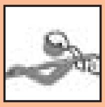
- Soviet approach: increase apple production in a region with ideal biophysical conditions.
- Farmers' initiative: to make more intensive use of agricultural lands through an agroforestry system, and especially to provide food security by growing annual crops between the trees.

Constraints addressed

	Specification	Treatment
Soviet approach		
Financial	The establishment and maintenance of the irrigation system, terraces and the orchards themselves required high financial input.	Equipment, seedlings and salaries were all provided by the soviet state.
Farmers' initiative		
Financial	Lack of funds for fertilizers, manure (which is burned as fuel for heating) and pesticides.	Improved fertility management: farmers developed cost – effective practices such as crop rotation and fallow periods, etc.

Participation and decision making

Target groups



Land users (farmers)

Teachers/ students/ school children*

* only in soviet times

Approach costs met by:

	Soviet approach	Farmers' initiative
National government	100%	
Community/local		100%
	100%	100%

Decisions on choice of the technology: Soviet approach: made by the state and local authorities. Farmers' initiative: mainly by land users supported by specialists.
Decisions on method of implementing the technology: Soviet approach: made by technical specialists. Farmers' initiative: mainly by land users supported by agricultural extension service (technical assistance).
Approach designed by: National specialists designed the approach to establish the orchards in the 1980s (soviet approach). Since 1993 it was the land users who designed the approach.

Community involvement

Phase	Involvement	Activities
Soviet approach		
Initiation	none	
Planning	none	
Implementation	payment	casual labour
Monitoring/evaluation	interactive	observations, public meetings, workshops
Research	passive	technology development in the Faizabad Horticulture Institute
Farmers' initiative		
Initiation	self-mobilisation	farmers' innovation: increase crop production by intercropping in orchards
Planning	self-mobilisation	responsibility for all the steps
Implementation	self-mobilisation / interactive	responsibility for all the steps, technical assistance from extensionists
Monitoring/evaluation	self-mobilisation	observations
Research	none	

Differences in participation between men and women: During soviet times, decisions within the collective farms were mainly made by men, though both men and women worked in the field. Nowadays a large number of men migrate to other countries to raise household income. Therefore most of the work during the summer lies on the shoulders of women. During spring, and part of the autumn, men are present and active in fieldwork.


left: Farmer bringing fodder home from the field: grass is cut between the fruit trees. (Hanspeter Liniger)
right: The farmer and his agroforestry system: a combination of pear trees and wheat. (Hanspeter Liniger)

Extension and promotion

Training: When the establishment of pure-stand orchards started in the 1980s under the soviet regime, the knowledge of farmers in the area of orchard implementation and maintenance was inadequate. Training was provided on-the-job, by public meetings and through courses. Training focused on improving irrigation, tree planting practices and tree management. Training conducted during the establishment of the orchards was useful and adequate. No training was given (naturally) in intercropping of wheat and other cereals between the rows of apple trees – the farmers' initiative. However in order to manage and adjust the land use system to today's situation, more training is needed.
Extension: For the running of the orchards during the soviet times a top-down/authoritarian approach was used: specialists/instructors led implementation in the field. All inputs were provided by the state, and farmers were used as casual labour. The bottom-up approach based on farmers' initiative for establishment of orchard/wheat intercropping worked through farmer-to-farmer extension. Farmers were supported by extension staff.
Research: During the original establishment of the orchards, research was conducted. For the new system of intercropping with wheat, research contributed by providing support with respect to choice of varieties.
Importance of land use rights: Allowing cropping on the farms was the first move; then land use rights were shifted from state to individual farmers. While those orchards which are still managed as state farms are often not well looked after, leasing of land and issue of landholder certificates generally leads to improved orchard management. However, access to land belonging to state farms (through lease agreements) is limited to people who have previously been members of those state farms.

Incentives

Labour: When the orchard plantations were originally established, people worked on state farms for cash wages. Nowadays labour is voluntary.
Inputs: Soviet approach: State provision of all inputs needed; Farmers' initiative: no inputs provided. Marginal farmers are supported by NGOs (Care International, German Agro Action) or WFP (the UN's World Food Programme under their 'Food-for-Work' Programme).
Credit: For the original establishment of orchards credit was provided by the state at a very low interest rate. Currently, for cultivating cereals and legumes, farmers have access to credit, but the interest rate is very high.
Support to local institutions: No support to local institutions – now or before.
Long-term impact of incentives: The fruit trees were established under the soviet system through paid labour, and thus represent an asset that can be used profitably. With respect to the new initiatives, there are no incentives involved.

Monitoring and evaluation

Monitored aspects	Methods and indicators	
	Soviet system	**Farmers' initiative**
Bio-physical	regular measurements (not specified)	ad hoc observations of erosion and crop growth – sedimentation and plant development
Technical	regular measurements: quantity of water per ha – irrigation infrastructure	–
Economic/production	regular measurements of income and yields	regular calculation of farmers' yield and profit
Area treated	regular measurements	ad hoc calculation
No. of land users involved	regular measurements	ad hoc observation

Impacts of the approach

Changes as result of monitoring and evaluation: None under either.
Improved soil and water management: Currently: moderate positive impact on soil and water conservation through the agroforestry system.
Adoption of the approach by other projects/land users: None known.
Sustainability: The soviet approach of orchards managed through state farms effectively died with the collapse of the Soviet Union: the irrigation system ceased to function and inputs were not provided anymore by the state. Furthermore, the land use system was not adapted to the farmers needs. To improve productivity of the current system and thus stimulate the farmers' approach, further external support (with equipment, seed, gasoline, extension support etc) is needed.

Concluding statements

Strengths and ➜ how to sustain/improve	**Weaknesses** and ➜ how to overcome
Soviet approach	**Soviet approach**
Well managed and controlled land use system with efficient irrigation system, high production, ensured maintenance, provision of fertilizers and technical assistance.	No diversity, mono-cropping system aimed at maximised production; as soon as state support ceased, the system collapsed.
Farmers' initiative	**Farmers' initiative**
Farmers are themselves finding a way out of the poverty trap ➜ Land reform should go further and every farmer should be eligible for land certificates/titles.	Land use rights: as long as the land still belongs to the state, people have very little motivation to improve it ➜ Privatise the land.
Farmers get diversified and additional products (grain, apples, beans, hay, etc) ➜ The government should support the farmers' initiatives. The marketing system of the fruits should be developed.	Further extension of the agroforestry system is limited without support from the extension service ➜ The extension service should provide more inputs.

Key reference(s): none
Contact person(s): Tabarov Abdugaffor, Dekhan Farm Mehrobod, District Faizabad ▪ Ergashev M, Soil Science Institute, Rudaki aven 21A, Dushanbe, Tajikistan; murod@swiss.tojikiston.com

left: A series of dohs temporarily filled with runoff water before infiltration. (David Gandhi)
right: Harvesting chilli peppers from land brought under irrigation through the effect of dohs. (William Critchley)

Sunken streambed structure

India – *Doh*

Excavations in streambeds to provide temporary storage of runoff, increasing water yields from shallow wells for supplementary irrigation.

Dohs are rectangular excavations in seasonal streambeds, which are intended to capture and hold runoff to enhance groundwater recharge, thus increasing water for irrigation from nearby shallow wells. They also collect and impound subsurface flow. *Dohs* are built in semi-arid areas where rainfall is low and seasonal.

The dimension of a typical *doh* is 1.0–1.5 m deep with variable length (up to 40 m) and width (up to 10 m) depending on streambed section, with an average capacity of 400 m^3. The excavated material is deposited along the stream banks as a barrier against siltation from surrounding areas. The slopes of the excavation are gentle (an upstream slope of 1:6 or 17% and a downstream slope of 1:8 or 12%) so that water flows into it, and excess water out again, carrying silt rather than depositing it. The sides however are steep, to increase capacity – and would benefit from stone pitching to stabilise them. A silt trap comprising a line of loose boulders is constructed upstream across the streambed. *Dohs* are generally built in sequence. They may be as close as a few metres apart. Bends in the stream are avoided as these are susceptible to bank erosion.

The technology is used in conjunction with shallow wells *(odees),* which enable farmers to harvest the increased groundwater for supplementary irrigation of annual crops – including vegetables such as chilli peppers. Water is pumped out of the wells. In the case study village, Mohanpada, each *doh* basically supplies an underground source of extra water to one well. Communities together with project staff carry out site selection, and then detailed design/estimates/layout is done with project technical assistance. As a supportive measure the catchment area is treated with gully plugs (small stone checks in gullies). A water harvesting tank (small reservoir or dam) may be excavated above the series of *dohs* where this is justified by a sufficiently large catchment area/suitable site. The capacity of the tank at Mohanpada is around 600 m^3 and thus also has a positive impact on groundwater recharge.

Maintenance is agreed through meetings of user groups: manual desilting is planned and repairs of gully plugs also. In summary, *dohs* are low cost water recharge alternatives for poorer communities, and in this case study, the extra area brought under production has meant that all families that require it, now have access to some water for irrigation.

Location: Mohanpada, Ratlam, Madhya Pradesh, India
Technology area: 0.1 km^2
SWC measure: structural
Land use: cropland and grazing land
Climate: semi-arid
WOCAT database reference: QT IND03
Related approach: Comprehensive watershed development, QA IND01
Compiled by: VK Agrawal and David Gandhi, Ratlam, Madhya Pradesh, India
Date: October 2002, updated June 2004

Editors' comments: Recharge structures for deep percolation of runoff and thus replenishment of groundwater for well-based irrigation are common features of Indian watershed management projects. The *doh* is innovative, being shallow, sited within a seasonally dry riverbed, and relatively cheap. This is a case study from a single village, Mohanpada, in Madhya Pradesh.

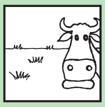
Classification

Land use problems

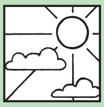
There are regular poor yields of agricultural crops on the degraded, rainfed fields. A further constraint is the limited amount of water in wells, restricting both the extent of irrigation, and the number of people with access to irrigation. There is an underlying problem of poverty, which in turn leads to seasonal out-migration to find work.

Land use | **Climate** | **Degradation** | **SWC measures**

annual crops: wheat, cotton, vegetables etc (irrigated)



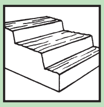
extensive grazing



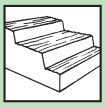
semi-arid

water degradation: soil moisture problem

water erosion: gully



structural: *doh* (sunken streambed structure)



structural: dam, gully plugs (supp.)

Technical function/impact

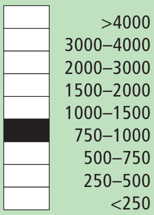
main: - water harvesting
- increase in infiltration

secondary: - control of concentrated runoff

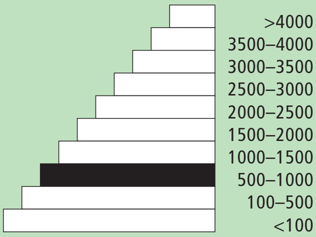
Environment

Natural environment

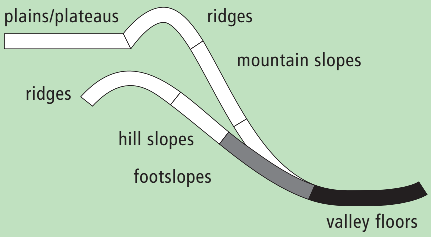
Average annual rainfall (mm)



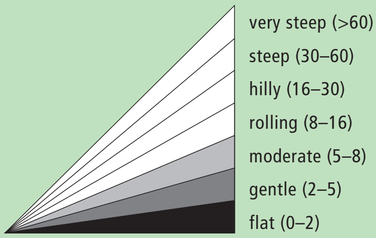
Altitude (m a.s.l.)



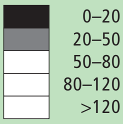
Landform



Slope (%)



Soil depth (cm)

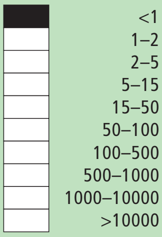


NB: soil properties before SWC

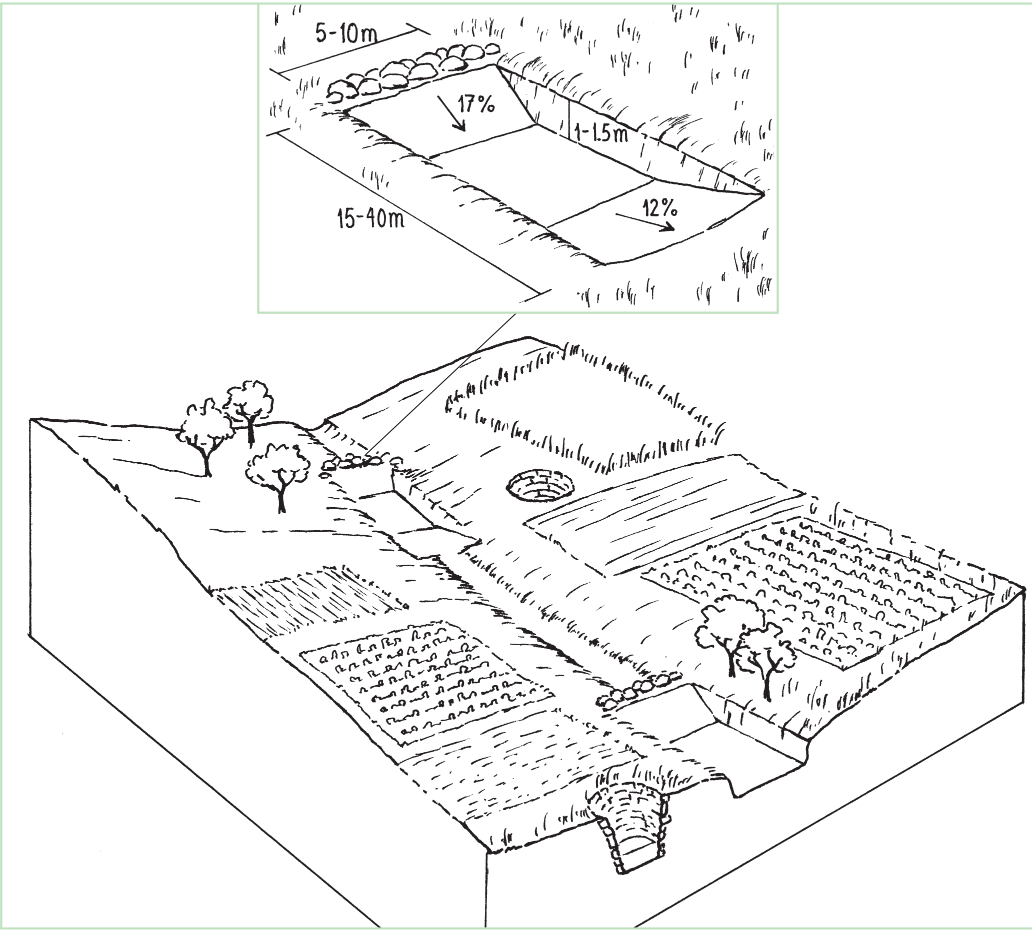
Growing period: 120 days (July to October, now with supplemental irrigation, extended through to January on some plots)
Soil fertility: mostly low, partly medium
Soil texture: mostly medium (loam), partly coarse (sandy)
Surface stoniness: mostly abundant loose stone
Topsoil organic matter: mostly low (<1%), partly medium (1–3%)
Soil drainage: medium
Soil erodibility: high

Human environment

Cropland per household (ha)



Land use rights: mainly individual, some open access (unorganised)
Land ownership: mainly individual titled, some communal/village
Market orientation: mixed (subsistence/commercial)
Level of technical knowledge required: field staff/extension worker: moderate, land user: low
Importance of off-farm income: 10–50% of all income: some migratory work in nearby towns and in large scale mechanised farms during peak periods (note: now there is less migration as a result of increased irrigation)



Technical drawing
Overview of sunken streambed structures *(doh)* with associated wells and irrigated plots. Note that several *dohs* are applied in series along the waterway.
Insert: Detail of a single sunken streambed structure. Gentle slopes in the direction of flow ensure minimal erosion of the structure, while lateral walls are steep to increase storage capacity (average 400 m^3). Stone barriers help avoid siltation of *dohs*.

Implementation activities, inputs and costs

Establishment activities

1. Site selection with the community by eye.
2. Identification of the beneficiaries and user groups.
3. Design and estimations by project staff using surveying instruments ('dumpy levels') and measuring tapes.
4. Agreement of village committee.
5. Catchment treatment begins – using hand tools: including water harvesting tank (capacity in this case about 600 m^3) and small gully plugs from earth or loose stone, as required.
6. Excavation of dohs (200–400 m^3) as last action with silt traps upstream of each made from loose stone.
7. Wells *(odees)* may be deepened and pumps bought – though those costs are not included here.

Duration of establishment: 1 year

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour (225 person days)	225	25%
Equipment		
- Tools	15	100%
Materials		
- Stone (2 m^3)	0	
TOTAL	**240**	**30%**

Maintenance/recurrent activities

1. Desilting of *dohs* in dry periods by hand.
2. Maintenance of catchment treatments (desilting of gully plugs etc) if required.

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Labour (5 person days)	5	100%
TOTAL	**5**	**100%**

Remarks: The construction of one *doh* costs between US$ 200–400, depending on the size of the *doh* (approximately one cubic metre can be excavated per person day at a cost of one US dollar). On a per hectare basis the costs are very variable, since they are related to the extra area brought under irrigation. In this case study there are four *dohs* within a total village area of 50 ha. Ten of the 50 ha have been brought into irrigated production (extra to the 5 ha already irrigated) due to the four *dohs* and the 'tank' and the costs outlined above are spread over those 10 ha. In this case half of the costs are directly attributable to *dohs* (average capacity 400 m^3 each), and half to catchment treatment where the water-harvesting tank (a reservoir of approximately 600 m^3) is the main cost. Where there is underlying rock, mechanical drills and blasting by dynamite may be required, which increases the costs. That was not the case in this village. The cost of deepening/widening the five wells *(odees)* has not been included here: that is carried out by the villagers themselves. While the project normally pays around 85% of labour costs, here at Mohanpada village the project only needs to pay 75%, due to a high level of commitment by the villagers.

Assessment

Acceptance/adoption

- All who implemented the technology did so with incentives – comprising wages from the project.
- Reasons for voluntary contributions (here representing 25% of costs) include visible production benefits.
- Spontaneous adoption is growing in neighbouring villages.

Benefits/costs according to land user

Benefits compared with costs	short-term:	long-term:
establishment	positive	very positive
maintenance/recurrent	positive	very positive

Impacts of the technology

Production and socio-economic benefits

+++	crop yield increase
+	farm income increase

Production and socio-economic disadvantages

–	increased economic inequity in some villages (between those with wells and those without)

Socio-cultural benefits

+++	improved knowledge SWC/erosion
++	community institution strengthening

Socio-cultural disadvantages

–	socio-cultural conflicts (see above)
–	reduced amount of water to downstream users

Ecological benefits

+++	groundwater increase
+++	increase in soil moisture
++	soil cover improvement (where cultivated)
++	soil loss reduction (in catchment)

Ecological disadvantages

none

Off-site benefits

+++	reduced downstream flooding
++	reduced downstream siltation
+	reduced river pollution
+	increased stream flow in dry season

Off-site disadvantages

–	reduced peak flows so downstream users may be deprived of some water

Concluding statements

Strengths and ➜ how to sustain/improve

Dohs are a low cost alternative method of increasing groundwater in a semi-arid area where production of high value legumes depends on irrigation – and *dohs* represent the best way in this situation of expanding the extent of irrigated land, and bringing irrigation to more families.

Small, multiple recharge points for replenishing groundwater for irrigation from wells ➜ Breaking hard pan in stream bed mechanically by drills or blasting to deepen *dohs* and thereby make them more effective.

No risk of breaches of bunds as the structures are sunken below ground.

Weaknesses and ➜ how to overcome

Group maintenance is required ➜ Form user groups.

Villagers are more used to (and may prefer) larger and deeper 'tanks' ➜ Establish more *dohs* to create more impact.

Dohs are limited in capacity and thus dry up quickly, as do the wells ➜ Establish more dohs to create more impact.

Key reference(s): none available – this is the first documentation

Contact person(s): Agrawal VK and Nayak T: danidain@mantrafreenet.com or pmdanida@sancharnet.in; Comprehensive Watershed Development Project, 22 Pratap Nagar, RATLAM – 457 001, MP, India ▪ David Gandhi: david_gandhi@yahoo.com

left: A community assembles to discuss the formation of a village development plan. (David Gandhi)
right: At Mohanpada, the village development plan is brought out to be shown to visitors. (William Critchley)

Comprehensive watershed development

India

Participatory approach that includes a package of measures leading to empowerment of communities to implement and sustain watershed development.

The approach adopted under the Comprehensive Watershed Development Project (CWDP) is intended to ensure sustainability of development interventions. This can only be achieved through creating a sense of 'ownership' amongst users, which means involving the community in planning, implementation and management of the interventions. A further, specific objective is to benefit vulnerable sections of the community.

Various methods are employed to achieve these goals. There is, first of all, awareness generation within the community through exposure visits outside the area, street theatre and video shows. After this comes the formation and capacity building of village level institutions, in particular the Village Watershed Development Committees (VWDCs). Users' groups are also formed. Micro-planning (under a 'village development plan') using participatory rural appraisal (PRA) follows. There are arrangements to ensure participatory execution of the plan, specifying cost and benefit sharing (on average 75%–90% of the work is paid for in cash under this approach). Another important element is to ensure user rights to resources. This entails negotiation with government for rights to produce from common land. Eventually, after initial implementation, management becomes the task of the users' groups: this includes maintenance, distribution of benefits and conflict resolution.

The whole process involves NGOs along with government staff in order to achieve better communication all round. The participants have different roles. Government staff (at various levels) provides technical and financial support, as well as assistance towards gaining user rights over resources. NGOs are particularly important in awareness generation and mobilisation, capacity building of village level institutions, and in the process of negotiation with the Government. The village committee is central in planning and implementation of the village development plan, and in overseeing users' groups. Users' groups are involved in planning, implementation and then resource management. The village assembly helps to identify beneficiaries and users, and to give overall support to the VWDC. An external international donor, DANIDA of Denmark, supports the Comprehensive Watershed Development Project.

Location: three watersheds around Ratlam, Madhya Pradesh, India
Approach area: 260 km^2
Land use: cropland and grazing land
Climate: semi-arid
WOCAT database reference: QA IND01
Related technology: Sunken streambed structure *(doh)*, QT IND03 – and other technologies
Compiled by: David Gandhi, DANIDA Advisor, Comprehensive Watershed Development Project, Ratlam, Madhya Pradesh, India
Date: September 2002, updated June 2004

Editors' comments: Participatory approaches to watershed development have been increasing in popularity over the last twenty years in India. There are many variations – depending on which organisation gives support. This is one example of a bilateral donor (DANIDA) working with a government agency.

Problem, objectives and constraints

Problem

- previous lack of consultation/involvement with the community in planning, implementation and management of watershed development interventions

Objectives

- create a sense of ownership amongst users
- ensure sustainability of technical and social interventions
- benefit more vulnerable sections of the community, including the poor and women
- involve the community in planning, implementation and management interventions

Constraints addressed

Major	Specification	Treatment
Social/cultural/religious	Competition between villages for resources of land and water.	Negotiations facilitated by NGOs.
Social/cultural/religious	Lack of awareness and mobilisation on improvement of production systems.	Awareness generation programme.
Minor	**Specification**	**Treatment**
Institutional	Lack of effective village institutions.	Formation and capacity building of various institutions.
Legal	Uncertainty over rights to access to resources.	Negotiations facilitated by NGOs.
Technical	High cost water harvesting measures.	Demonstration of low cost alternatives such as the *doh* (sunken structure in dry riverbed to increase infiltration of runoff, which replenishes wells for irrigation: see 'related technology').

Participation and decision making

Target groups


Land users


SWC specialists/ extensionists


Teachers/school children/students

Approach costs met by:

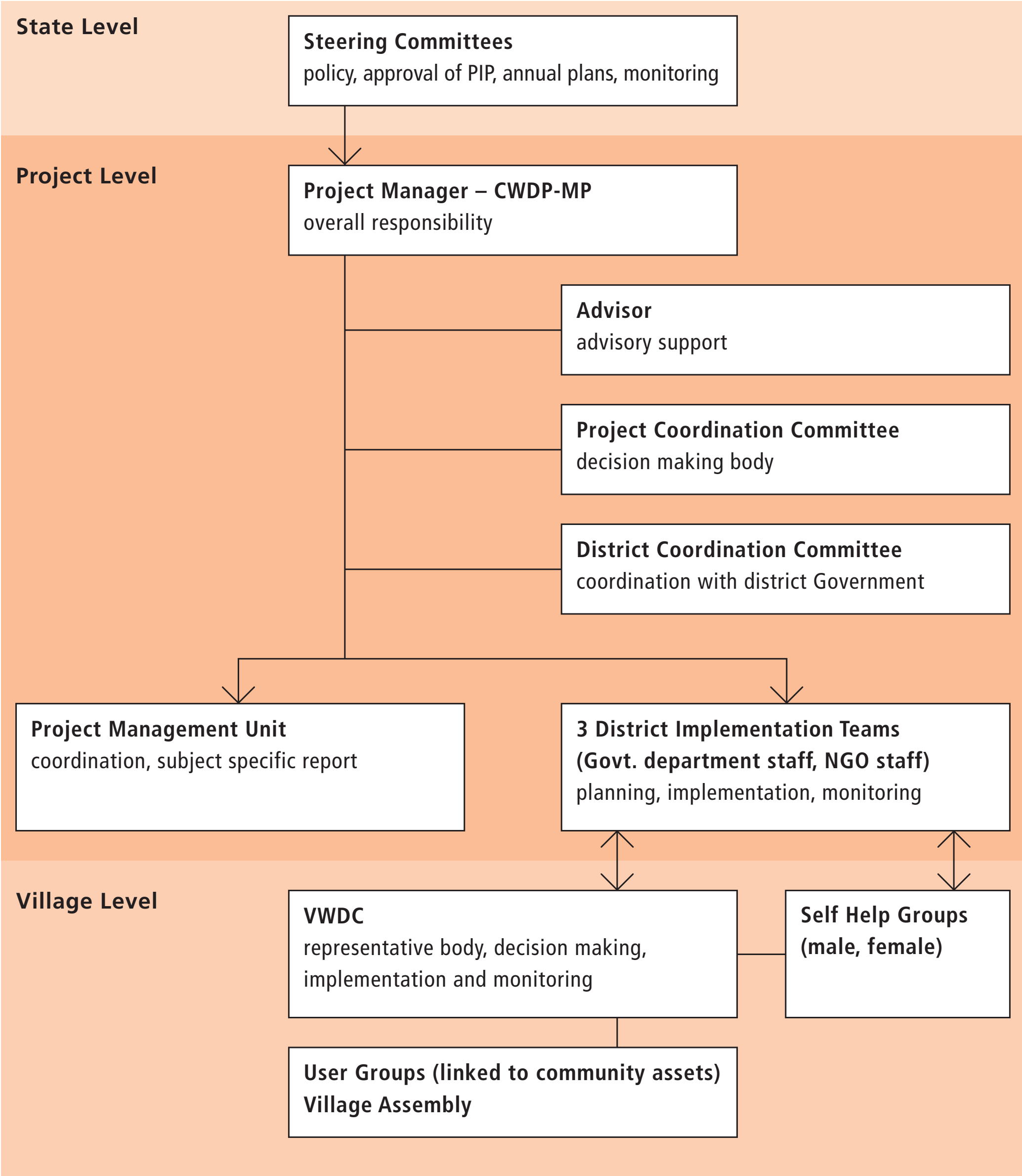
International agency	85%
National government	5%
Community/local	10%
	100%

Decisions on choice of the technology: Mainly by SWC specialists with consultation of land users: 'exposure visits' to outside demonstration sites are used as a tool for sensitisation, motivation and awareness raising.
Decisions on method of implementing the technology: Mainly by land users – through village groups – supported by SWC specialists.
Approach designed by: National and international specialists.

Community involvement

Phase	Involvement	Activities
Initiation	interactive	public meetings/awareness generation
Planning	interactive	PRA/discussion and negotiations
Implementation	interactive	responsibility for minor steps/land users provide labour
Monitoring/evaluation	interactive	measurements/observations by community with project staff
Research	passive	studies carried out by project staff

Differences in participation between men and women: Men traditionally make decisions. The project has worked towards involving women more, especially in self-help groups.



Organogram
CWDP-MP: Comprehensive Watershed Development Project in Madhya Pradesh

PIP: Project Implementation Plan

VWDC: Village Watershed Development Committee

Extension and promotion

Training: There are courses, on the job training, and exposure visits. These are provided by government and NGO staff. Training concentrates on participatory approaches and low cost technologies. Capacity building for community groups and land users enables them to participate better in projects and to take ownership of assets. Effectiveness of the training has been fair.
Extension: National and State Government policies nowadays emphasise the 'participatory approach'. Extension has been delivered through multidisciplinary teams from Government departments, and village level workers through various NGOs. However Government – NGO cooperation needs now to be institutionalised. Effectiveness of extension has generally been good.
Research: Research has had little impact on the programme's effectiveness.
Importance of land use rights: Although ownership rights have generally not been a problem, people didn't want to carry out SWC on Government land, and weren't allowed to do so on Forest Department land. The NGOs involved however acted as intermediaries in negotiations and helped solve the problems, ensuring user rights in some cases.

Incentives

Labour: As is common in Indian watershed development initiatives, there is a substantial subsidy towards labour involved. Under this approach 75–90% of the labour input is paid for in terms of cash: the remainder is a voluntary contribution.
Inputs: Machinery is fully financed: hand-tools are not subsidised.
Credit: None is provided.
Support to local institutions: As noted in the introductory description, there is considerable help given to institutions – through finance and training provided by the project.
Long-term impact of incentives: There is dependency created in the short-term on wages, but this will decrease when higher yields of crops (partially because of increased irrigation) become apparent and when there is no need for further investment in infrastructure.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	regular observations of general parameters
Technical	regular measurements of water levels in some wells
Socio-cultural	ad hoc measurements of (reduced) migration
Economic/production	regular measurements of yield
Area treated	ad hoc observations of hectares treated
No. of land users involved	regular measurements of attendance at meetings
Management of approach	none

Impact of the approach

Changes as result of monitoring and evaluation: Several technological changes have taken place as a result of a review: for example feedback on yield data led to crop variety recommendations. Levels of water in wells confirmed impact of the 'sunken structures' *(dohs).*
Improved soil and water management: This was 'moderate'/fairly successful.
Adoption of the approach by other projects/land users: The approach has not yet been widely adopted, but the State Department of Agriculture has begun to expand this approach to other projects.
Sustainability: At this early stage outside support is still required before the villages can be left to manage and sustain the improvements.

Concluding statements

Strengths and ➜ how to sustain/improve
Government system can be strengthened by co-operation with NGOs in watershed management projects ➜ Continue dialogue between partners at various levels.
Land users are developing a strong sense of ownership of the assets created (in terms of cost-sharing, a local contribution of up to 25% is high in Indian contexts) ➜ There needs to be continued support for 2–3 years after phasing out of bio-physical watershed development activities; also important to build up village funds through a 'community contribution' charge deducted from wages.
Systematic approach to strengthen community participation ➜ Detailed 'process documentation' to be continued.
Leadership developed at village level ➜ NGOs should continue to advise/guide/monitor activities.
Marginalised groups have been identified and given a 'say' ➜ NGOs should continue to advise/guide/monitor activities.
Awareness has been raised about SWC through drama and exposure visits ➜ Continue, and include visits to successful income generating projects.
Participatory planning has led to better understanding of resources and possibilities ➜ The entire village plan should be implemented in defined stages to allow impact to be noted/felt.

Weaknesses and ➜ how to overcome
Because of low literacy levels NGO support to village level institutions is required for more than just short-term ➜ Adult literacy classes of sufficient duration are needed.
PRA brings out many social factors that are beyond the scope of the project to influence eg the feudal system ➜ NGOs need to have broad-based activity platforms that can address these issues as they arise.
Shortage of female staff restricts contact with women ➜ Gender sensitisation training needed for project staff.
Women are not adequately involved in exposure visits ➜ Correct this imbalance/arrange separate visits for women.
Project duration for planning and implementation too short ➜ Increase the timespan to 3 years or more.
A 'community contribution' charge is currently deducted equally from all villagers by the project from wages paid ➜ Should be a greater voluntary contribution from the richer farmers.
Segregation of responsibilities between Government and NGO staff ➜ Better integrated teamwork should be the goal.

Key reference(s): none
Contact person(s): Nayak T: danidain@mantrafreenet.com or pmdanida@sancharnet.in, Comprehensive Watershed Development Project, 22 Pratap Nagar, RATLAM – 457 001, MP India ▪ David Gandhi: david_gandhi@yahoo.com

left: Adding manure to the pits *(tassa)* before planting. (William Critchley)
right: Stone lines in combination with *tassa:* the two measures act together to capture runoff and improve plant performance. (Charles Bielders)

Planting pits and stone lines

Niger – *Tassa avec cordon pierreux*

Rehabilitation of degraded land through manured planting pits, in combination with contour stone lines. The planting pits are used for millet and sorghum production on gentle slopes.

The combination of planting pits *(tassa)* with stone lines is used for the rehabilitation of degraded, crusted land. This technology is mainly applied in semi-arid areas on sandy/loamy plains, often covered with a hard pan, and with slopes below 5%. These denuded plains are brought into crop cultivation by the combination of *tassa* and stone lines. Planting pits are holes of 20–30 cm diameter and 20–25 cm depth, spaced about 1 m apart in each direction. The excavated earth is formed into a small ridge downslope of the pit. Manure is added to each pit, but its availability is sometimes a problem. At the start of the rainy season, millet or sorghum is sown in these pits. The overall aim of the system is to capture and hold rainfall and runoff, and thereby improve water infiltration, while increasing nutrient availability.

Stone lines are small structures, at most three stones wide and sometimes only one stone high. The distance between the lines is a function of the slope and availability of stone. Typically they are sited 25–50 m apart on 2–5% slopes. Stones are usually collected from nearby sites – though sometimes up to 5–10 km away – and brought to the fields by donkey carts or lorries (when a project is involved). They are positioned manually, along the contour. Stone lines are intended to slow down runoff. They thereby increase the rate of infiltration, while simultaneously protecting the planting pits from sedimentation.

Often grass establishes between the stones, which helps increase infiltration further and accelerates the accumulation of fertile sediment. Wind-blown particles may also build up along the stone lines due to a local reduction in wind velocity. The accumulation of sediment along the stone lines in turn favours water infiltration on the upslope side. This then improves plant growth, which further enhances the effect of the system. Construction does not require heavy machinery (unless the stones need to be brought from afar by lorry).

The technique is therefore favourable to spontaneous adoption. Stone lines may need to be repaired annually, especially if heavy rains have occurred. Manure is placed every second (or third) year into the previously dug pits and sand is removed annually: normally the highest plant production is during the second year after manure application.

Location: Tahoua, Niger
Technology area: 40 km^2
SWC measure: structural
Land use: mixed (silvo-pastoral) and wasteland (before), cropland (after)
Climate: semi-arid
WOCAT database reference: QT NIG02
Related approach: Participatory land rehabilitation, QA NIG01
Compiled by: Oudou Noufou Adamou, Tahoua, Niger
Date: August 1999, updated June 2004

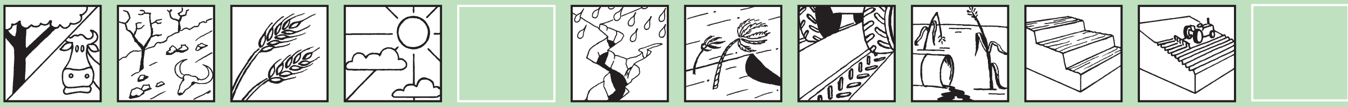
Editors' comments: The combination of planting pits and stone lines is becoming increasingly common throughout the West African Sahel. It is based on traditional methods, and was pioneered on the Central Plateau of Burkina Faso. It is best with application of manure or compost, and is thus most suitable to mixed farming systems. Stone lines are most appropriate when there is abundant loose stone close by: in flat stone-free areas planting pits may be used alone.

Classification

Land use problems

Soil fertility decline is the basic problem: this is due to degradation and nutrient mining. Loss of limited rainwater by runoff and loss of soil cover result in low crop production and food insufficiency. This occurs in combination with lack of pasture, resulting in shortage of manure.

Land use | **Climate** | **Degradation** | **SWC measures**



silvo-pastoral: footslopes (before) | wasteland: denuded, crusted plateaus (before) | annual crops: millet and sorghum (after) | semi-arid | water erosion: loss of topsoil | wind erosion: loss of topsoil | physical: soil compaction/ crusting | chemical: fertility decline | structural: stone lines, planting pits | agronomic: manure application (supp.)

Technical function/impact

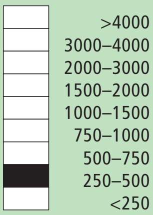
main:
- increase in infiltration
- increase/maintain water stored in soil
- water harvesting
- increase in organic matter
- increase in soil fertility
- increases natural regeneration of trees

secondary:
- reduction of slope length
- improvement of soil structure
- improvement of ground cover

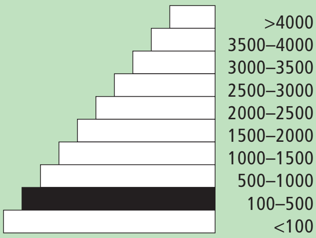
Environment

Natural environment

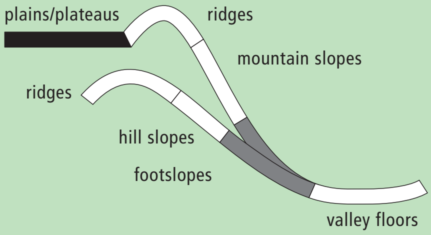
Average annual rainfall (mm)



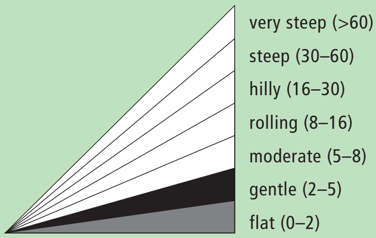
Altitude (m a.s.l.)



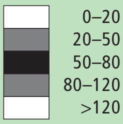
Landform



Slope (%)



Soil depth (cm)

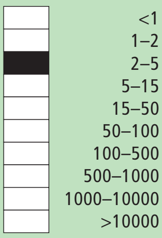


NB: soil properties before SWC

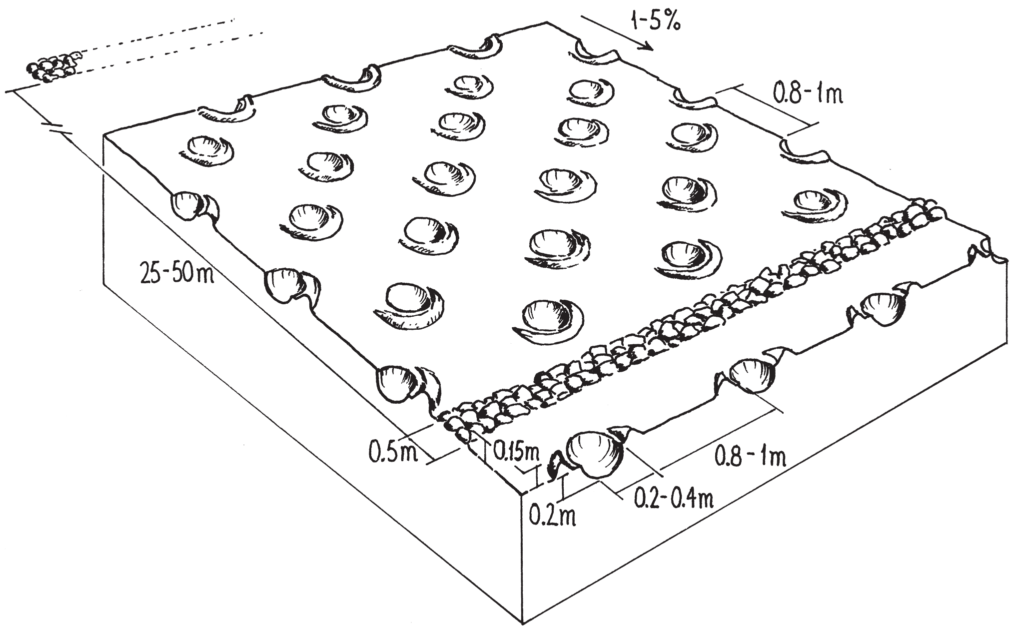
Growing season: 90 days (June to September)
Soil fertility: mostly low, partly very low
Soil texture: mainly coarse (sandy) partly medium (loam)
Surface stoniness: no loose stone on footslopes, some loose stone on plains
Topsoil organic matter: low (<1%)
Soil drainage: good, though infiltration is low where there is a crust
Soil erodibility: varied, depending on presence of surface crust

Human environment

Cropland per household (ha)



Land use rights: individual
Land ownership: mostly individual titled
Market orientation: mostly subsistence (self-supply), partly mixed (subsistence and commercial)
Level of technical knowledge required: field staff/extension worker: moderate, land user: low
Importance of off-farm income: >50% of all income: remittances from out-migration of labour, commerce and crafts



Technical drawing
Planting pits *(tassa)* capture rainfall runoff for cultivation of annual crops, and the stone lines – spaced at 25–50 metres apart – help hold back moisture and eroded soil.

Implementation activities, inputs and costs

Establishment activities

1. Digging pits *(tassa)* with a hoe in the dry season: the excavated earth forms ridges downslope of the hole. The pits are spaced about 1 m apart, giving approximately 10,000 pits/ha.
2. Digging out stones from nearby sites using a pick-axe and shovel.
3. Transporting stones with donkey cart or lorries.
4. Aligning the stones along the contour with the help of a 'water tube level': maximum of 3 stones wide.
5. Manuring the pits with approx 250 g per pit (2.5 t/ha).

All activities carried out in the dry season (November to May).
Duration of establishment: 1 year

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour for digging *tassa* (100 person days)	150	100%
Labour stone lines (25 person days)	40	100%
Equipment		
- Transporting stones with lorries 85–10 km)	40	0%
- Tools for *tassa*	5	100%
- Tools for stone lines	5	75%
Materials		
- Stone (50 m³)	0	
Agricultural		
- Compost/manure (2.5 t)	5	100%
TOTAL stone lines	**85**	**52%**
TOTAL *tassa*	**160**	**100%**
TOTAL stone lines and *tassa*	**245**	**83%**

Maintenance/recurrent activities

1. Removing sand from the *tassa* (annually, March–May).
2. Manuring the pits with about 250 g per pit (2.5 t/ha) every second year in October/November or March-May.
3. Check and repair stone lines annually and after heavy rains.

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Labour *tassa* (20 person days)	30	100%
Labour stone lines (1 person days)	1.5	100%
Equipment		
- Tools *tassa*	1	100%
Agricultural		
- Compost/manure (1.25 t)	2.5	100%
TOTAL	**35**	**100%**

Remarks: The costs are based on 300 m of stone lines per hectare (on a 3–4% slope). Maintenance costs refer to removing sand from the pits from the second year onwards, and to the application of manure every second year (costs are spread on an annual basis). If applicable, costs for transporting the manure need to be added. The general assumption in these calculations is that adequate manure is readily available close by. The availability of stones is the main factor in determining costs – though labour availability can affect prices also. If stones are not available in the field or nearby (from where they can be transported by donkey cart), they have to be carried by lorries, which is much more expensive. The costs here refer to fuel costs only, paid by a project: they do not include depreciation of lorries.

Assessment

Acceptance/adoption

All villagers accepted the technology with incentives of some hand tools and provision of transport for the collection of the stones (by lorries where necessary), which ensured a higher participation. There is moderate growing spontaneous adoption (for rehabilitation of the plains), but there are no estimates available regarding the extent.

Benefits/costs according to land user

Benefits compared with costs	short-term:	long-term:
establishment	positive	very positive
maintenance/recurrent	positive	very positive

Impacts of the technology

Production and socio-economic benefits

- +++ crop yield increase
- ++ farm income increase

Socio-cultural benefits

- ++ improved knowledge SWC/erosion
- \+ community institution strengthening through mutual aid in technology implementation

Ecological benefits

- ++ long-term soil cover improvement
- ++ increase in soil moisture
- ++ increase in soil fertility
- ++ increase in organic matter
- ++ soil loss reduction

Off-site benefits

- \+ reduced downstream flooding
- \+ reduced downstream siltation

Production and socio-economic disadvantages

- −− increased labour constraints
- −− increased input constraints

Socio-cultural disadvantages

- − land use rights conflicts of rehabilitated land
- − conflicts between farmers and pastoralists because pasture land is being turned into cultivated fields

Ecological disadvantages

- − waterlogging in planting pits after heavy rains

Off-site disadvantages

none

Concluding statements

Strengths and ➜ how to sustain/improve

Simple technology, individually applicable in the dry season, requiring only very little training/knowledge and no special equipment.

Making best use of manure, which is a limiting resource.

Increase in agricultural production.

Rehabilitation of degraded and denuded land: bringing back into production formerly uncultivated land; extension of farm land to the plateaus.

Weaknesses and ➜ how to overcome

Labour demanding technology for implementation and maintenance ➜ Mechanisation of tasks: transportation of stones and manure. However, this would raise the cost.

Instability of planting pits in loose soil, increased erosion on steeper slopes and with heavier rains ➜ Avoid loose sandy soils and steep slopes.

The effectiveness can be compromised if the various geo-morphological units (plateaus, slopes) are not treated simultaneously ➜ Catchment area approach if downstream flooding is an issue.

Possibility of land use conflicts concerning rehabilitated land, in particular with pastoralists ➜ Better coordination/consultation before implementing the technology in an area.

Implementation constraint: availability of manure and/or stones and transporting manure/stones to the plateaus and slopes ➜ Subsidise transport means (or supply donkey carts) or/and apply stone lines only in areas where there are stones available close to the fields.

Key reference(s): Bety A, Boubacar A, Frölich W, Garba A, Kriegl M, Mabrouk A, Noufou O, Thienel M and Wincker H (1997): *Gestion durable des ressources naturelles. Leçons tirées du savoir des paysans de l'Adar.* Ministère de l'agriculture et de l'élevage, Niamey, 142 pp. ■ Hassane A, Martin P and Reij C (2000) *Water harvesting, land rehabilitation and household food security in Niger: IFAD's Soil and Water Conservation Project in Illela District.* IFAD, Rome, 51 pp. ■ Mabrouk A, Tielkes E and Kriegl M (1998) Conservation des eaux et des sols: Leçons des connaissances traditionnelles de la région de Tahoua, Niger. In: Renard, G., Neef, A,. Becker, K. and Von Oppen, M. (eds). *Soil fertility management in West African land use systems.* Proceedings of the Regional Workshop, 4-8 March 1997, Niamey, Niger. Margraf Verlag. Weikersheim/Germany. pp. 469–473.
Contact person(s): Charles Bielders, Dept. of Environ. Sciences and Land Use Planning – Agric. Engineering Unit, The Faculty of Bio-engineering, Agronomy and Environment, Université catholique de Louvain, Croix du Sud 2, boite 2, B-1348 Louvain-la-Neuve, Belgium, bielders@geru.ucl.ac.be ■ Eric Tielkes, Centre for Agriculture in the Tropics and Subtropics, University of Hohenheim, 70593 Stuttgart, Germany, tielkes@uni-hohenheim.de

left: A female extension worker showing the men of the village how to dig *tassa* – water harvesting planting pits. (Philippe Benguerel)
right: Harvested millet: production in the driest areas is possible through technologies promoted under projects with an appropriate approach. (William Critchley)

Participatory land rehabilitation

Niger – *Approche participative de récupération des terres individuelles et collectives*

Planning and management of individual and village land, based on land users' participation, with simultaneous promotion of women's activities.

This approach is integral to the Tahoua Rural Development Project, PDRT *(Projet de Développement Rural de Tahoua),* a long-term project, which was initiated in 1988 and has been financed mainly through the German and Nigerien governments, but with voluntary participation and contributions from the local population.

The main goal of the approach is to plan and implement land management activities with villagers in such a way that sustainability is ensured. The specific objectives of the project are to: (1) increase the capacity of the villagers to design, implement and self-evaluate SWC activities; (2) develop and document management programmes for the village land; (3) restore and protect the agrosilvopastoral production potential; (4) develop and evaluate activities for the benefit of rural women; and (5) improve the capacity of government and private development agencies to coordinate and execute sustainable land rehabilitation. The technical focus of PDRT's approach is evident in its title. The project emphasises simple and cheap technologies that are replicable. Project extension work is carried out by facilitators and consists of awareness raising, demonstration and exchange trips.

Problem identification and planning of activities takes place in village meetings. The local land users are supported by project personnel who also provide technical assistance during the implementation of SWC measures.

Incentives are provided for the rehabilitation of marginal land for silvo-pastoral use, but nothing is given for individual agricultural land, other than the transport of stones using lorries – for those fields that do not have stones close by.

Through village groups and with the help of development agencies, the people of Tahoua district have succeeded in implementing measures to improve living conditions on a sustainable basis. However continuation of the approach is not ensured due to two major reasons: (1) land users do not have the means to carry on the activities on common land and (2) the government lacks the capacity and finance for extension. The project supported services stopped completely in 2003 – however a new programme began in 2004 with German cooperation and is currently attempting to use NGOs for extension work.

Location: Tahoua, Niger
Approach area: approx.700 km^2
Land use: mixed (silvo-pastoral) and wasteland (before), cropland (after)
Climate: semi-arid
WOCAT database reference: QA NIG01
Related technology: Planting pits and stone lines, QT NIG02
Compiled by: Oudou Noufou Adamou, Tahoua, Niger
Date: July 1998, updated June 2004

Editors' comments: Participatory approaches to SWC were developed by projects throughout the West African Sahel during the 1980s as a response to drought and land degradation. This particular approach is specific to the *Projet de Développement Rural de Tahoua*, in Niger and has been implemented over an area of approx. 700 km^2 since 1988. Together with improved rainfall over the last decade, such approach-technology combinations have been largely responsible for the recent widespread 'regreening' of many parts of the Sahel.

Problems, objectives and constraints

Problem

- previously the ‘beneficiaries’ of land rehabilitation programmes did not feel responsible/accountable and therefore were difficult to mobilise for voluntary participation in activities
- there had been no co-ordination and consultation between implementing agencies and organisations
- there was general degradation of the agrosilvo-pastoral ecosystem, and associated low returns from the land

Objectives

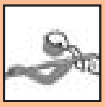
The general objective is to develop a participatory way of developing and implementing simple soil and water conservation measures – and ensuring sustainability by involving local people – with the overall goal of improving the status of the degraded ecosystem and uplifting the living conditions of the rural population.

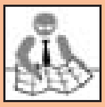
Constraints addressed

Major	Specification	Treatment
Legal	Land ownership.	Application of the ‘rural code’, a legal instrument; however it does not sufficiently cover land access rights, therefore SWC technologies on common land can lead to exclusion of pastoralists who had former access to these sites.
Social	Missing (mainly male) labour due to seasonal out-migration.	Demonstrate technologies to improve the land and thus increase its profitability to reduce out-migration and search for less labour-intensive options.
Financial	Lack of financial resources of local groups for long term investments in SWC.	Create land users groups which can seek financial support together.
Minor	**Specification**	**Treatment**
Institutional	The government has neither the means nor the capacity to implement SWC everywhere.	Create decentralised bodies, eg farmer and pastoralist co-operatives.
Legal	Conflicts between various users of natural resources (eg farmers vs pastoralists).	Meetings and training on co-utilisation of certain resources, establishment of communally managed grazing schemes.
Social/cultural	Poor diffusion of information because of high illiteracy levels.	Adult literacy teaching, visual and/or oral extension forms (eg posters, theatre, radio).
Religious	Fatalism: ‘God is responsible’.	Need to change mentality through training.
Institutional	Lack of coordination between projects.	Regional and national coordination.

Participation and decision making

Target groups


Land users


Planners


Politicians/
decision makers

Approach costs met by:

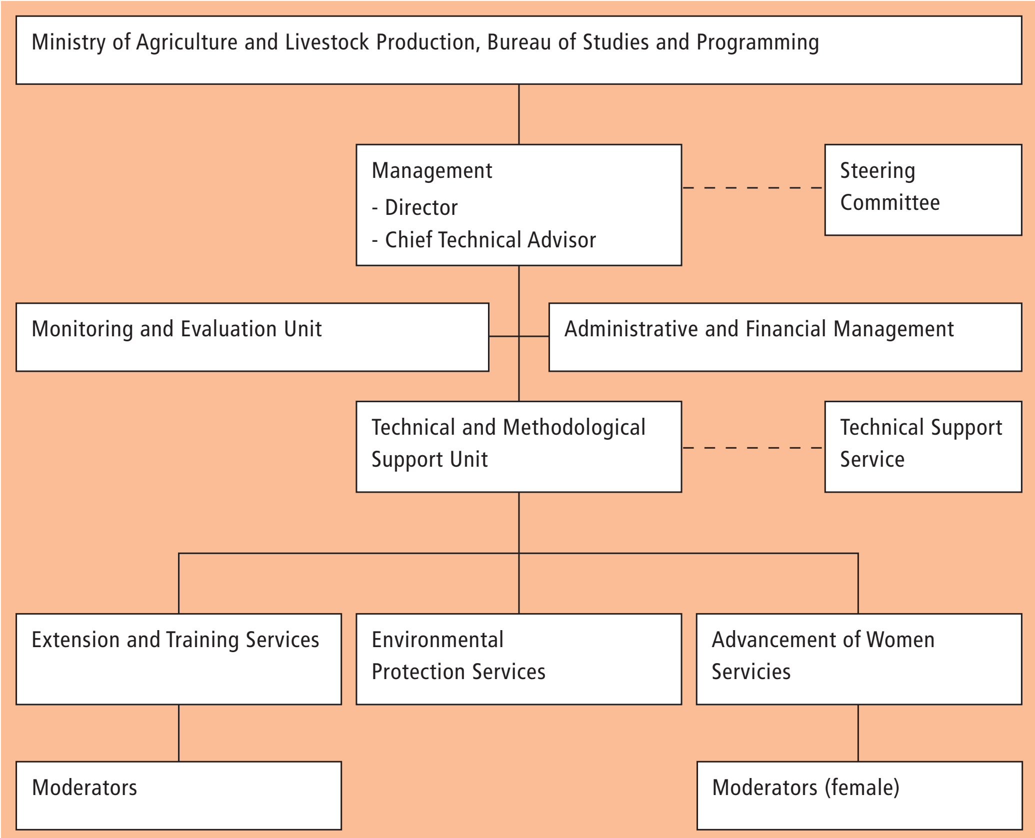
International agency	80%
National government	5%
Community/local	15%
	100%

Decision on choice of the technology: Made by land users supported by SWC specialist through village meetings, consultations, and participatory village assessments.
Decision on method of implementing the technology: Made by land users supported by SWC specialists during planning and training processes.
Approach designed by: National and international specialists.

Community involvement

Phase	Involvement	Activities
Initiation	self-mobilisation/interactive	problem identification in village meetings
Planning	interactive	self-evaluation of planning in village meetings
Implementation	self-mobilisation for individual land, payment/incentive for communal land	farmers supervised through project personnel
Monitoring/evaluation	interactive	through field observations (measurement of biomass development on certain sites) and self-evaluation in village meetings
Research	interactive	on-farm and on-station

Differences in participation between men and women: The participation of women is higher in community work (on common lands), partly because of seasonal out-migration of men. Work on individual fields is done mainly by men, but with a high participation of women during certain tasks – eg sowing and harvesting. Most women have small plots of land to cultivate by themselves.



Organogram
Organisational set-up of participatory land rehabilitation approach.

Extension and promotion

Training: Training is carried out through public meetings, farm visits, courses, demonstration areas and hands-on practice. Target groups were first extensionists/trainers, then land users and also students. The training has generally been effective.
Extension: Project extension work is carried out by facilitators (extension staff) and consists of awareness raising, demonstration and exchange trips. The government extension service is unable to continue the work at the same level due to limited financial means. Effectiveness of extension on land users has been poor due to lack of coordination in planning and follow-up evaluation between project and extension services.
Research: On-farm research on technology and sociology is part of the approach. These include characterisation of SWC measures (with an emphasis on traditional technologies), and analysing problems of food-for-work, amongst other sociological studies. Some of this research was carried out by the project and some studies were carried out by local sociologists. No local research institutions were directly involved.
Importance of land use rights: At the outset, existing land ownership/land use rights were neglected and have therefore moderately hindered the implementation of the approach. The original objectives of SWC on common lands was to produce millet. However implementation took place without regard to existing land rights on these sites. As soon as people saw that it was possible to produce millet using this technology on these degraded lands, they brought forward historical claims and disputes developed as a result – though, more positively, in several areas a land market evolved. After these first experiences, PDRT stopped applying SWC technologies on common lands for crop production; instead the project changed focus towards silvo-pastoral production. Even this has provoked problems between agriculturalists and pastoralists.

Incentives

Labour: Labour is mostly voluntary, but partly rewarded with incentives. Food is provided for rehabilitation of marginal land for silvo-pastoral use, but nothing is given for individually owned agricultural land.
Inputs: The project has provided hand tools free of charge, occasionally subsidised seeds and tree nurseries, and furthermore has provided community infrastructure including roads and community buildings for meetings.
Credit: No credit was provided.
Support to local institutions: Local institutions received some support, essentially through training.
Long-term impact of incentives: A moderate negative impact is likely. In general, measures on individual fields are carried out and maintained well, without material incentives, but on communal land nothing is done without incentives (because of little interest, no direct profit, and the need for hard work). Local management structures for these rehabilitated sites will need to be developed by user groups.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	regular measurements of area of improved land
Technical	regular measurements of area treated with various technologies
Economic/production	regular measurements of biomass production, yield of herbs, development of planted trees
Management of approach	regular measurements of finances, personnel, logistics, inputs used

Changes as result of monitoring and evaluation: There have been several changes since 1988. The project was reoriented from a focus merely on productivity towards a natural resources management approach. In 1990, anti-erosion technologies were introduced, and 1993/94 saw the start of a more comprehensive land management approach.
Improved soil and water management: There have been moderate improvements through establishment of the various SWC measures.
Adoption of the approach by other projects/land users: Various other projects in Niger – around six in total – have adopted the approach.
Sustainability: On common lands, land users will not be able to expand activities because they don't have the means (money, tools, lorries to transport stones, organisation) and they have no access to loans for implementation. However application of certain SWC technologies on individual fields – such as planting pits *(tassa)* or 'half moons' *(demi-lunes)* continues without any outside support.

Concluding statements

Strengths and ➜ how to sustain/improve
Builds upon and improves indigenous knowledge of land users ➜ Self-evaluation is already sufficient to discuss weak points, successes and next steps.
Training and self-supervision of villagers ➜ Continue training, include all user groups, work out management schemes for reclaimed common lands.
Awareness creation about environmental issues and the importance of SWC technologies ➜ Continue this awareness creation.
Increased production – most spectacularly on formerly abandoned areas ➜ Ensure maintenance of SWC technologies.
Improvement of village infrastructure: including roads and wells ➜ Continue with project/outside support as long as is possible.

Weaknesses and ➜ how to overcome
The approach does not deal directly with out-migration of the young people ➜ Train young people (16–25 years): organise meetings and give ideas, for example: (1) rent cropland in small groups and grow vegetables during the dry season for sale; (2) train groups of SWC specialists.
Uncertain continuation: no formal decentralised body composed of villagers has been set up to take over functions currently under the project ➜ Provide sufficient training in terms of planning and also in skills to search for financial support.
Disregarding existing land use rights led to conflicts between agriculturalists and pastoralists ➜ The project changed focus from crop production to silvo-pastoral production (see 'Importance of land use rights').

Key reference(s): Winckler H, Hertzler G (1996) *Préserver les coutumes, préparer l'avenir.* Présentation du PDRT, GTZ, Eschborn ■ Tielkes E (1998) Communally managed rotational grazing on reclaimed pastures in the northern Sahel. In: Lawrence P, Renard G and von Oppen M (eds) (1999) *Evaluation of technical and institutional options for small farmers in West Africa.* Margraf Verlag, Weikersheim/Germany. pp. 63–68 ■ Lycklama à Nijeholt R, Tielkes E and Bety A (2001) L'exploitation des pâturages aménagés : deux ans d'expériences au PDRT. In: Tielkes E, Schlecht E and Hiernaux P (eds). *Elevage et gestion de parcours, implications pour le développement.* Comptes-rendus d'un atelier régional ouest-africain sur 'La gestion des pâturages et les projets de développement: quelles perspectives?' October 2000, Niamey, Niger. Verlag Grauer, Beuren-Stuttgart/Allemagne. pp. 55–61.
Contact person(s): Charles Bielders, Dept. of Environ. Sciences and Land Use Planning – Agric. Engineering Unit, The Faculty of Bio-engineering, Agronomy and Environment, Université catholique de Louvain, Croix du Sud 2, boite 2, B-1348 Louvain-la-Neuve, Belgium, bielders@geru.ucl.ac.be ■ Eric Tielkes, Centre for Agriculture in the Tropics and Subtropics, University of Hohenheim, 70593 Stuttgart, Germany, tielkes@uni-hohenheim.de

left: Runoff harvesting for olive trees by up-and-down tillage (by tractor) and V-shaped microcatchments (dug by hoe) in a semi-arid area, Khanasser Valley, Aleppo, Syria. (Francis Turkelboom)
right: Runoff is collected in micro-basins around each tree. The V-shaped bunds extend to the left. Stone mulching – as a supportive measure – further enhances moisture conservation by reducing evaporation (see picture in related approach). (Francis Turkelboom)

Furrow-enhanced runoff harvesting for olives

Syria – إستغلال أثلام الفلاحة لحصاد المياه في بساتين الزيتون

Runoff harvesting through annually constructed V-shaped microcatchments, enhanced by downslope ploughing.

The Khanasser Valley in north-west Syria is a marginal agricultural area, with annual rainfall of about 220 mm/year. Soils are shallow and poor in productivity. The footslopes of degraded hills are traditionally used for extensive grazing or barley cultivation. However to achieve self-sufficiency in olive oil production, several farmers have developed orchards in this area – which is generally considered too dry for olives.

Trees are spaced at 8 m apart, within and between rows. Traditionally, farmers prefer to till their orchards by tractor in order to keep them weed-free (weeds may attract sheep, lead to fires and compete for water with the olive trees). As this tillage operation is usually practised up and down the slope, the resulting furrows stimulate runoff and erosion. However, when this is combined with V-shaped and/or fish-bone shaped microcatchments around individual trees, the furrows created can be used to harvest runoff water for improved production.

The V-shape earthen bunds (reinforced with some stones) are constructed manually, by hoe, around each tree. The furrows then divert runoff systematically to the microcatchments where it concentrates in basins around the trees. Each tree is effectively served by a catchment area of 60 m^2. The catchment: cultivated area ratio is thus approximately 60:1 (assuming the area exploited by the tree roots to be, initially at least, one square metre).

This technology saves irrigation water during the dry season, enhances soil moisture storage, and stimulates olive tree growth. Furthermore, fine particles of eroded soil are captured in the microcatchments. While these may be nutrient-rich, they also tend to seal the surface. The bunds need to be rebuilt every year. If the structures are damaged after a heavy storm, they need to be repaired. Labour input for establishment and maintenance is low, the technology is easy and cheap to maintain, and there is enough local skill to sustain and expand the system.

A supporting technology is to mulch the area around each tree with locally available stones (limestone and/or basalt) to reduce soil temperature during the summer, decrease surface evaporation and improve infiltration. The catchment areas between the trees are sometimes planted with low water-demanding winter annuals (lentils, vetch, barley, etc) especially when the trees are young. This helps to reduce surface erosion. Implementation of furrow-enhanced runoff water harvesting in olive orchards started in 2002, and adoption by farmers is growing gradually.

Location: Harbakiyeh and Habs, Khanasser Valley, Aleppo, NW Syria
Technology area: 0.05 km^2
SWC measure: agronomic and structural
Land use: grazing land (before), cropland: orchard (after) and mixed: silvo-pastoral (after)
Climate: semi-arid
WOCAT database reference: QT SYR03
Related approach: Participatory technology development, QA SYR03
Compiled by: Francis Turkelboom, Ashraf Tubeileh, Roberto La Rovere, Adriana Bruggeman, ICARDA, Aleppo, Syria
Date: November 2004, updated April 2005

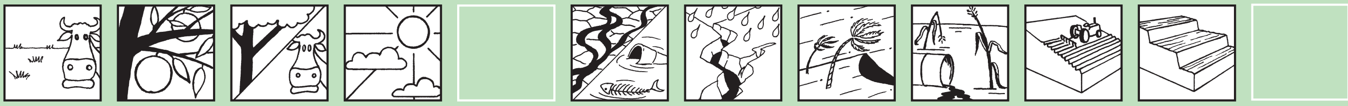
Editors' comments: Microcatchment runoff harvesting for tree planting in dry areas is a common practice worldwide. There are many traditional and project-introduced systems. This case study is an example developed jointly by researchers and farmers for olive trees in Syria.

Classification

Land use problems

There are a series of problems in this area, including: low and erratic rainfall, drought, low land productivity, poor water use efficiency, land degradation, limited ground water for irrigation, few agricultural options, and low income from agriculture.

Land use | **Climate** | **Degradation** | **SWC measures**



extensive grazing (before) | tree crops: olives (after) | silvo-pastoral: olives, barley, ext. grazing (after) | semi-arid | water degradation: aridification, low soil moisture | water erosion: loss of topsoil | wind erosion: loss of topsoil | chemical: fertility decline, reduced organic matter content | agronomic: up and down tillage (for runoff collection) | structural: V-shaped bunds, mulching with stone

Technical function/impact

main:
- water harvesting
- retain/trap dispersed runoff
- increase water stored in soil

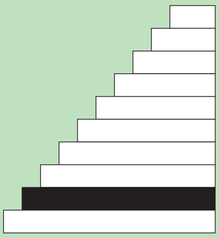
secondary:
- reduction of slope length
- sediment harvesting
- reduction in wind speed

Environment

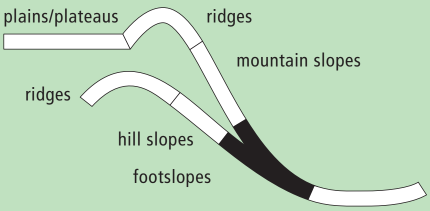
Natural environment

Average annual rainfall (mm)

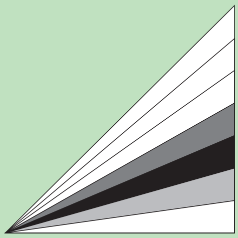
Altitude (m a.s.l.)



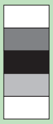
Landform



Slope (%)



Soil depth (cm)



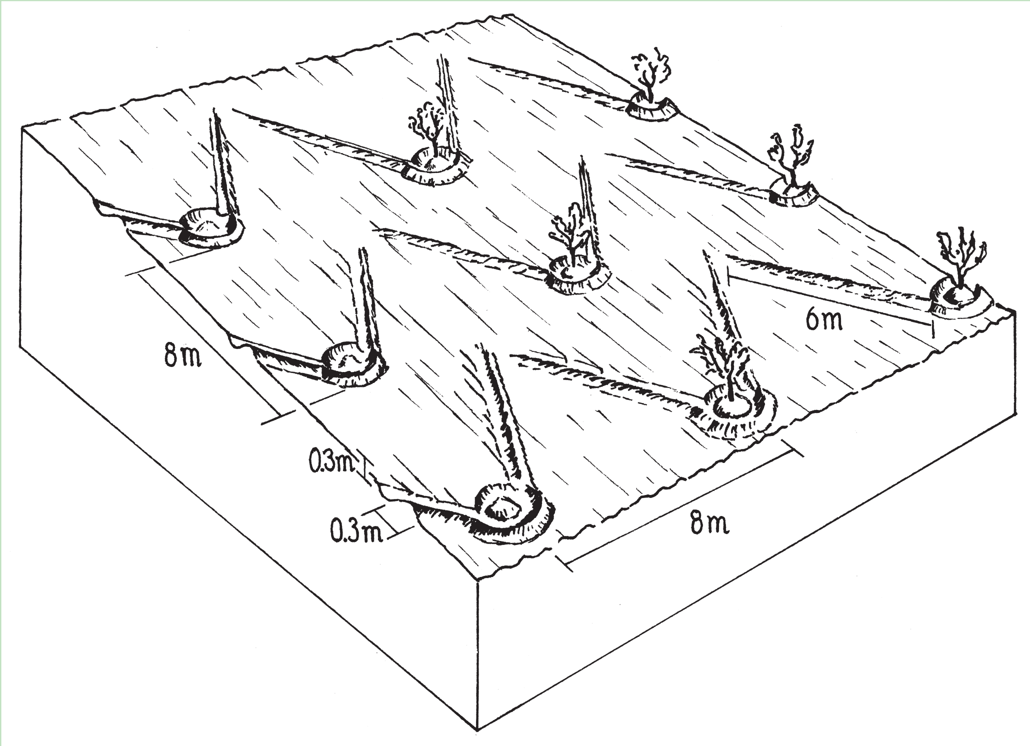
NB: soil properties before SWC

Growing season: 150 days (December to April)
Soil fertility: mostly low, partly very low
Soil texture: medium (loam)
Surface stoniness: mostly some loose stone, partly abundant loose stone
Topsoil organic matter: low (<1%)
Soil drainage: medium to high
Soil erodibility: medium

Human environment

Mixed land per household (ha)

Land use rights: individual
Land ownership: individual
Market orientation: mixed (subsistence/commercial)
Level of technical knowledge required: field staff/extension worker: low, land user: low
Importance of off-farm income: 10–50 % of all income: from farm labour and non-agricultural activities in nearby cities



Technical drawing
V-shaped micro-catchments which harvest water for the olive trees: the furrows up-and-down slope help channel the runoff to the olives.

Implementation activities, inputs and costs

Establishment activities

V-shaped bunds are seasonal structures and thus established every year. Specifications are given under recurrent activities (see below).

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
not applicable		

Maintenance/recurrent activities

1. Up-and-down tillage by tractor-driven plough; in winter (November/December; beginning of rainy season).
2. Construction of runoff harvesting bunds and micro-basins, manually by hoe (November/December; beginning of rainy season).
3. Maintenance of bunds in winter/rainy season, after heavy rainfall; 1–3 times/year.

Labour for establishment of water harvesting structures: 10 person days; for repair: 5 person days.

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Labour		
- Construction (10 person days)	50	100%
- Repair (5 person days)	25	100%
Equipment		
- Machines (tractor rent)	10	100%
- Tools (hoe)	3	100%
Materials		
- Earth (in-situ available)	0	
TOTAL	**88**	**100%**

Remarks: The calculation covers the runoff harvesting technology alone – annual activities of ploughing and water harvesting structure establishment and maintenance. Planting of olive trees and their maintenance are not included here.

Assessment

Acceptance/adoption

- Generally moderate adoption: The technology is mainly applied by 'agriculturalists', that is households whose livelihoods mainly depend on agriculture. Farmers with more interest in off-farm labour or sheep rearing were less interested in adopting the technology.
- All of the land users who accepted the technology did so without receiving incentives – this was spontaneous adoption.
- The technology is expanding slowly but gradually.
- Reasons for adoption are, first, savings on the cost of irrigation water during the summer (fast returns); second, improved olive yield (long term benefit).

Benefits/costs according to land user

Benefits compared with costs	short-term:	long-term:
establishment	not applicable*	not applicable*
maintenance/recurrent	positive	not applicable**

* establishment is annual, see benefits compared to costs under maintenance/recurrent

** too early to define (olive trees still young)

Impacts of the technology

Production and socio-economic benefits

+ +	water saving
+ +	better tree growth
+	crop yield increase

Production and socio-economic disadvantages

– –	depends on availability of tractor
–	hindered farm operations
–	increased weed growth around trees
–	increased labour constraints

Socio-cultural benefits

+ +	improved knowledge SWC/erosion
+	improved landscape and environmental quality

Socio-cultural disadvantages

none

Ecological benefits

+ + +	soil loss reduction
+ + +	reduced runoff
+ +	increase in soil moisture
+	increase in soil fertility
+	reduction of wind velocity
+	biodiversity enhancement

Ecological disadvantages

none

Off-site benefits

+	reduced downstream flooding
+	reduced downstream siltation

Off-site disadvantages

–	reduced runoff for infiltration in valley bottom
–	reduced sediment yields in valley bottom

Concluding statements

Strengths and ➜ how to sustain/improve

Increases soil moisture storage in low rainfall areas and allows expansion of olive plantation into drier areas ➜ Use organic amendments (mulch or manure), and more stone mulching.

Easy, low-cost and requires no extra external inputs.

Reduces soil erosion.

Reduces summer irrigation needs ➜ Use of localised (drip) irrigation will further reduce overall irrigation needs.

Improves olive productivity ➜ Rip land prior to planting to achieve further gains.

Weaknesses and ➜ how to overcome

Extra labour needed ➜ Construct during off-season.

Increases weed growth in the tree basin ➜ More stone mulching.

Trees will still need some irrigation in summer ➜ Make irrigation practices more efficient.

Key reference(s): Tubeileh A and Turkelboom F (2004) *Participatory research on water and soil management with olive growers in the Khanasser Valley.* KVIRS project, ICARDA, Aleppo, Syria ▪ Tubeileh A, Bruggeman A and Turkelboom F (2004) *Growing olive and other tree species in marginal dry environments.* ICARDA, Aleppo, Syria

Contact person(s): Francis Turkelboom – F.Turkelboom@cgiar.org ▪ Ashraf Tubeileh - A.Tubeileh@cgiar.org ▪ Adriana Bruggeman – A.Bruggeman@cgiar.org ▪ All from ICARDA, Aleppo, Syria; Fax: 00-963-(0)21-221.34.90; Tel: 00-963-(0)21-221.34.33; www.icarda.org

left: Joint field visit including farmers and ICARDA researchers to a local innovator's field – Harbakiyah, Khanasser Valley, NW Syria. (Francis Turkelboom)
right: Priority ranking of problems for growing olives. The exercise took place at ICARDA's facilitation office at Harbakiyah, Khanasser Valley, and involves Khanasser farmers, a community facilitator, researchers from ICARDA, and development workers. (Francis Turkelboom)

Participatory technology development

Syria – تطوير التقانات التشاركي

Participatory technology development, through close researcher-farmer interaction, for sustainable land management of olive orchards in dry marginal areas.

The purpose of participatory technology development is to gain from the synergy between indigenous knowledge and scientific expertise. The specific objective in this case was to develop and test water and land management techniques in order to sustainably improve olive production in a semi-arid area, while ensuring that the techniques were well adapted to local farming practices. The approach consists of group meetings, joint field trips, identification of local innovations, extension days, monitoring of farmer practices, and researcher-controlled experiments. The approach consists of a cycle with three major stages: a diagnostic phase, a testing phase, followed by monitoring and evaluation.

In this case study, farmers were invited based on their interest in growing olives. Participation throughout the learning cycle was completely voluntary: no material or financial incentives were used (although they expected them in the beginning of the process). The role of farmers was to identify priority problems and potential solutions, to test new technologies on their farms, and to evaluate their suitability.

Farmers observed the research experiment with water harvesting, and then adapted the technology to their needs. As shown, they built V-shaped bunds around their olive trees to capture rainwater runoff, but – contrary to the researchers' suggestion – they continued to plough the olive orchards, as this is their standard weed control practice. Weeds attract sheep, lead to fires and compete for water with the olives. This simple runoff harvesting system is well adapted to farmers' objectives, and their modification – the up-and-down slope furrows created through ploughing – actually serves to increase the efficiency of the water harvesting. The system is now being monitored by researchers to assess its technical and economic efficiency.

Improved farmer-researcher interaction helps farmers learn about a useful basic technique from researchers, while researchers learn in turn about potential improvements to the technology from local innovators. A community facilitator of ICARDA (International Centre for Agricultural Research in Dry Areas) facilitated the group discussions, and the researchers were asked to be open-minded to new approaches while conducting and monitoring field trials. The approach was tested by an interdisciplinary team of ICARDA as part of the 'Khanasser Valley Integrated Research Site'. This project aimed to develop local-adapted options for agriculture in dry marginal areas alongside a generally applicable integrated approach for sustainable land management in these zones.

Location: Khanasser Valley, NW Syria.
Approach area: 0.05 km^2
Land use: grazing land (before), cropland: orchard (after) and mixed: silvo-pastoral (after)
Climate: semi-arid
WOCAT database reference: QA SYR03
Related technology: Furrow-enhanced runoff harvesting for olives, QT SYR03
Compiled by: Francis Turkelboom, Ashraf Tubeileh, Roberto La Rovere, Adriana Bruggeman, ICARDA, Aleppo, Syria
Date: April 2005

Editors' comments: Participatory technology development (PTD) has recently become accepted as a viable alternative to researchers acting independently from the land users. PTD implies a partnership between farmers and researchers, with the farmers' priorities put first. Joint experiments are carried out, and assessed together by both parties. This is a promising example from Syria. PTD is also a feature of the moroccan case study, 'Ecograze' from Australia and PFI from Uganda.

Classification

Problem
The lack of appropriate ways to develop sustainable technologies to remedy loss of runoff water and poor olive growth – in the context of low-input agriculture on gentle undulating land in water scarce areas with an absence of soil conservation measures.

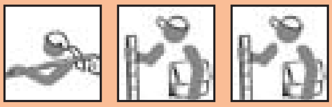
Objectives
- design, test and disseminate alternative technologies adapted to local conditions
- strengthen local knowledge of SWC measures
- strengthen joint learning by farmers and researchers

Constraints addressed

Major	Specification	Treatment
Financial	Water harvesting is considered expensive due to labour cost.	Identification of a low-cost water harvesting measure, which can be implemented during the off-season. Cost-benefit analysis.
Technical	Difficulty in tilling the land when water harvesting structures are in place.	Integrating local innovations into the water harvesting system.
Minor	**Specification**	**Treatment**
Technical	Uncertainty about appropriate size of micro-catchment area.	Researcher-controlled research.
Technical	Uncertainty about the amount of water harvested.	Researcher-controlled research.
Technical	Lack of technical expertise for olive crop husbandry in dry areas.	Carry out farmer field days, disseminate and elaborate extension leaflets.

Participation and decision making

Target groups



Land users SWC specialists/ extensionists Researchers

Approach costs* met by:

International agency	50%
National government	10%
Community/local	40%
	100%

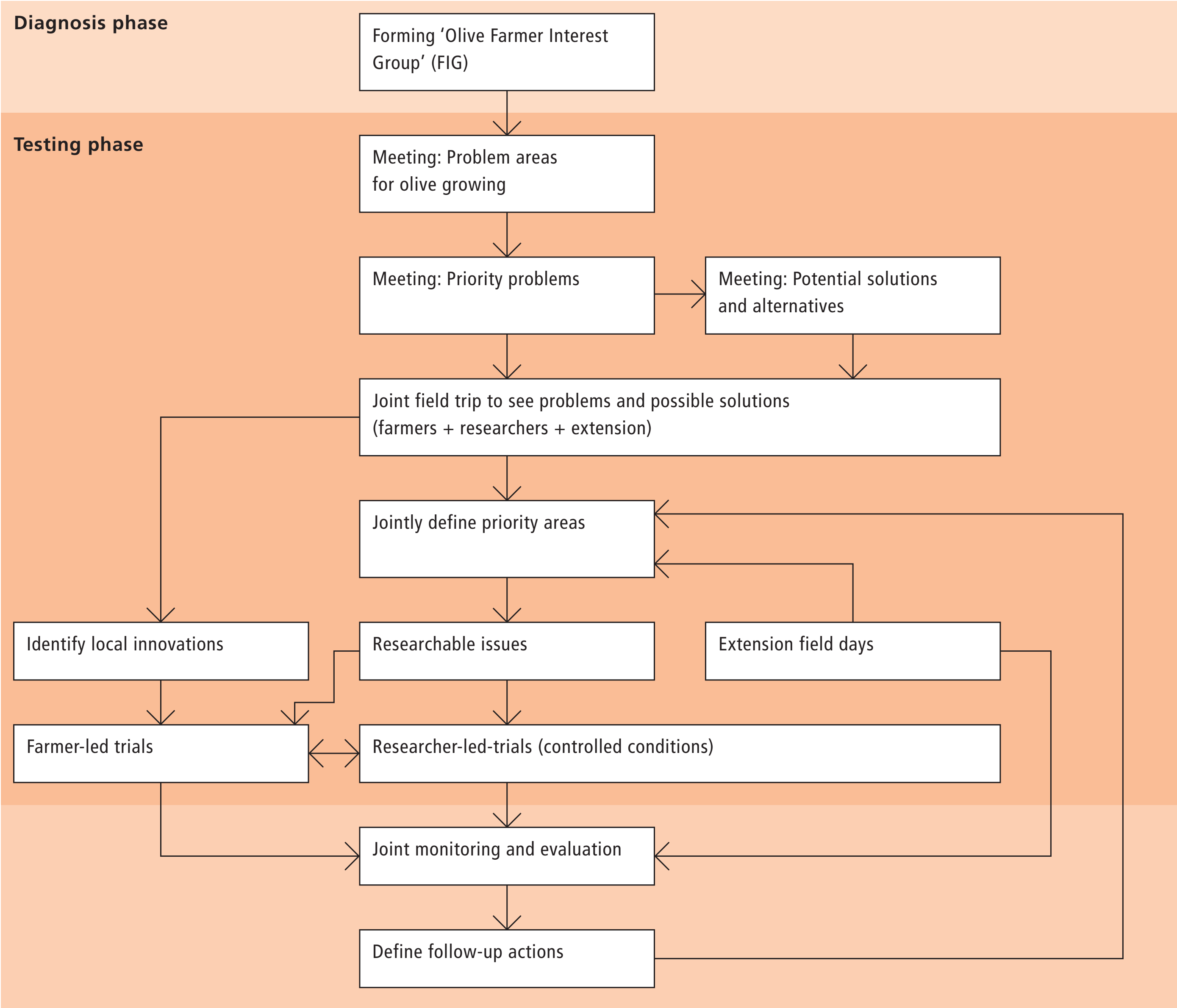
*Major approach costs: time of participating farmers, community facilitator, extension staff and researchers.
Sponsors: BMZ (Germany), ICARDA, Atomic Energy Commision of Syria (AECS). Support by Olive Research Division of Syria and Extension of Sfire

Decisions on choice of the technology: Mainly made by land users supported by SWC specialists.
Decisions on method of implementing the technology: By land users only.
Approach designed by: International specialists.

Community involvement

Phase	Involvement	Activities
Initiation	passive	public meetings
Planning	interactive	public meetings
Implementation	self-mobilisation	completely conducted by land-users
Monitoring/evaluation	passive/interactive	interviews and public meetings
Research	interactive	farmer experiments and controlled on-farm experiments

Differences in participation between men and women: Mainly men were involved, as most activities in olive orchards are managed by men. In addition, culturally bound gender segregation in public makes it difficult to organise gender-mixed meetings. Therefore, separate meetings were organised for women. In the case of one household, the de facto partner was a woman who takes most of the orchard-related decisions and does the work herself.



Approach process
Phases and methods of participatory technology development. (Francis Turkelboom)

Extension and promotion

Training: Demand-driven training of olive husbandry techniques (eg pruning, grafting, pest management) was conducted through public meetings, farm visits and on-the-job training. Training was reasonably effective.
Extension: Farmer-to-farmer extension was used: innovative farmers showed their technique to other olive farmers during farm visits. It was quite effective in spreading the idea among interested farmers. Extension in marginal agricultural areas is usually ill-equipped to facilitate such extension activities without outside support.
Research: Research was an important part of this approach. Technical and socio-economic topics were treated as follows: (1) Researcher-controlled on-farm experiments: this helped evaluate the impact of water harvesting design on the amount of water harvested and the olive crop response. (2) Monitoring of farmer-managed trials: to evaluate the performance of water harvesting under on-farm conditions. (3) Cost-benefit analysis: to check economic viability. (4) Analysis of perception of advantages and disadvantages of the technology.
Research was reasonably important for the effectiveness of the approach, as it provided better insights into constraining factors for water harvesting, and helped to clarify the potential amount of water saved.
Importance of land use rights: All water harvesting was done in private olive orchards. Secure land tenure was essential to invest in water harvesting structures.

Incentives

Labour: Labour was voluntary.
Inputs: No inputs were provided.
Credit: No credit was provided.
Support to local institutions: The approach facilitated technical interaction between interested olive growers in the area.
Long-term impact of incentives: Not applicable (the approach did not use any incentives).

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	regular observations and measurements (eg soil moisture)
Technical and management of approach	annual observation of water harvesting structures and management measures
Socio-cultural	ad hoc (twice) analysis of perceptions of the technology
Economic/production	ad hoc (once) analysis of cost and benefits
Area treated	annual field survey (using GPS)
No. of land users involved	annual farmer interview

Impact of the approach

Changes as a result of monitoring and evaluation: There were few changes: interest in the farmers' orchards and questions about the technology stimulated some other farmers to apply water harvesting.
Improved soil and water management: Adoption of the furrow-enhanced runoff-water harvesting technique resulted in a concentration of scarce rainwater and nutrients in the basins around the olive trees. The consequence is a significant reduction of soil loss and runoff at the field level.
Adoption of the approach by other projects/land users: This approach is now being applied in other ICARDA-coordinated projects in the region.
Sustainability: The complete PTD process/learning cycle needs outsider facilitation, but lack of outsiders will not stop farmers experimenting further by themselves. In terms of the technology itself, farmers can continue independently with water harvesting structures, as the system is very simple and relatively cheap.

Concluding statements

Strengths and ➜ how to sustain/improve
Engagement of researchers with local innovators and thus interaction between scientific and indigenous knowledge ➜ This approach can only be sustained if it is mainstreamed into national research and extension services.
Attitude changes by researchers about farmers' knowledge ➜ Ditto.
Building on local knowledge ➜ Ditto.
Capacity building of both land users and researchers ➜ Ditto.
Demand-driven technologies ➜ Ditto.

Weaknesses and ➜ how to overcome
Time demanding ➜ Less time needed after the first experience.
Appropriate facilitating skills required ➜ Mainstreaming facilitation skills.

Key reference(s): Tubeileh A and Turkelboom F (2004) *Participatory research on water and soil management with olive growers in the Khanasser Valley.* KVIRS project, ICARDA, Aleppo, Syria ■ van Veldhuizen L, Waters-Bayer A, Abd de Zeeuw H (1997) *Developing technology with farmers: a trainer's guide for participatory learning.* Zed Books, Londen, UK
Contact person(s): Francis Turkelboom – F.Turkelboom@cgiar.org ■ Ashraf Tubeileh – A.Tubeileh@cgiar.org ■ Adriana Bruggeman – A.Bruggeman@cgiar.org ■ All from ICARDA, Aleppo, Syria, fax 00-963-(0)21-221.34.90; tel 00-963-(0)21-221.34.33; www.icarda.org

left: A fully developed check dam: The stem cuttings – in this case associated with *Bromelia pinguin* – have grown to form a dense living barrier, and the area behind the dam has become level. (Mats Gurtner)
right: Check dams made of rooted tree stems reduce the speed of runoff water in the gully and trap sediment. (Mats Gurtner)

Check dams from stem cuttings

Nicaragua – *Diques de postes prendedizos*

Gully rehabilitation by check dams made of stem cuttings from trees. These living barriers retard concentrated runoff and fill up the gullies gradually with sediment.

Stem cuttings from specific tree species have the ability to strike roots and continue growing after being planted into the earth. In this case study local species have been used to create check dams in gullies: these include *jinocuebo (Simaroubaceaes bombacaceaes,* and also *jobo, tiguilote, pochote* from the same family). Other suitable species are *jocote (Spondias purpurea)* and *madero negro (Gliricidia sepium).* As an option the pinapple-like *piñuela (Bromelia pinguin)* can be planted in association with the stem cuttings to further reinforce the system.

Tree stems are cut into pieces 5–15 cm thick and 1.5–2.5 m long, depending on the depth of the gully. The cuttings are planted to half of their length, and formed into semi-circular barriers (see diagram). The dams retard runoff and thus retain eroded sediment. Spacing between dams depends on the gradient of the gully bed. For example on a 15% slope it is recommended to build a dam every 4 meters (see spacing under establishment activities). Between dams, the gully gradually fills up with eroded soil, the speed of the runoff is further reduced and agricultural land that has been divided by the gully is reconnected. Large and deep gullies may change over time into a sequence of narrow fertile terraces where crops can be grown.

However, the check dams should be seen as part of an integrated catchment management and protection plan, and thus be supported by other SWC measures on the lateral slopes, such as retention ditches and/or live barriers laid out along the contour. Erosion and runoff control on the sides of each gully is an essential part of the rehabilitation process. These check dams of rooted poles are more robust and durable than stone dams in soils of sandy/loamy texture. On moderate and steep slopes a combination of stem cutting and stone dams is recommended. After two to three years the barriers should be pruned – yielding wood and fodder. Dead poles should be replaced and the dam widened if necessary.

In this case study the dams are constructed in a semi-arid region with erratic rainfall where gullies are common on agricultural land, be it cropland or grazing land. The land users are mainly peasant farmers, growing crops for subsistence on smallholdings, and living in very poor conditions. This system of gully rehabilitation is promoted by an NGO entitled *'Asociación Tierra y Vida'* through farmer-to-farmer *(campesino a campesino)* extension.

Location: Santa Teresa, Paso de la Solera, Carazo, Nicaragua
Technology area: 5 km^2
SWC measure: structural
Land use: cropland, grazing land
Climate: semi-arid
WOCAT database reference: QT NIC04
Related approach: not documented
Compiled by: Reinerio Mongalo, *Asociación Tierra y Vida* (AT&V), Nicaragua
Date: April 2000, updated February 2004

Editors' comments: Various forms of vegetative control of gullies are widespread throughout the world. This particular form – the use of stem cuttings – has the advantage of establishing live barriers rapidly. One of the trees used in this case study, *madero negro (Gliricidia sepium)*, is also known and utilised for the same purpose in various other countries.

Classification

Land use problems

There is a range of factors that limit agricultural production in the area: soil degradation, extensive gully formation on crop land, low soil fertility, lack of inputs for crop production, erratic precipitation. Also, lack of interest/knowledge and lack of resources hinder the implementation of SWC measures.

Land use | **Climate** | **Degradation** | **SWC measures**

annual crops | extensive grazing | semi-arid | water erosion: gully erosion | structural: check dams; retention ditches | vegetative: stem cuttings; live barriers along contour (supp.)

Technical function/impact

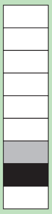
main: - control of concentrated runoff (trap/retain)
- levelling of land

secondary: - reduction of slope angle
- reduction of slope length

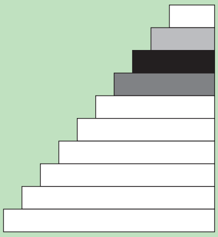
Environment

Natural environment

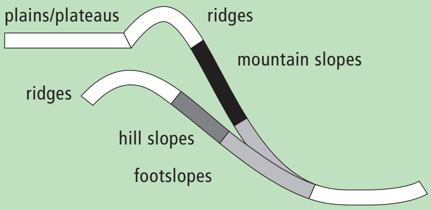
Average annual rainfall (mm)



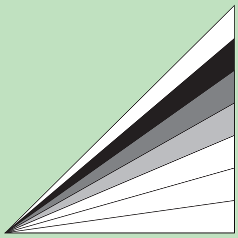
Altitude (m a.s.l.)



Landform



Slope (%)



Soil depth (cm)

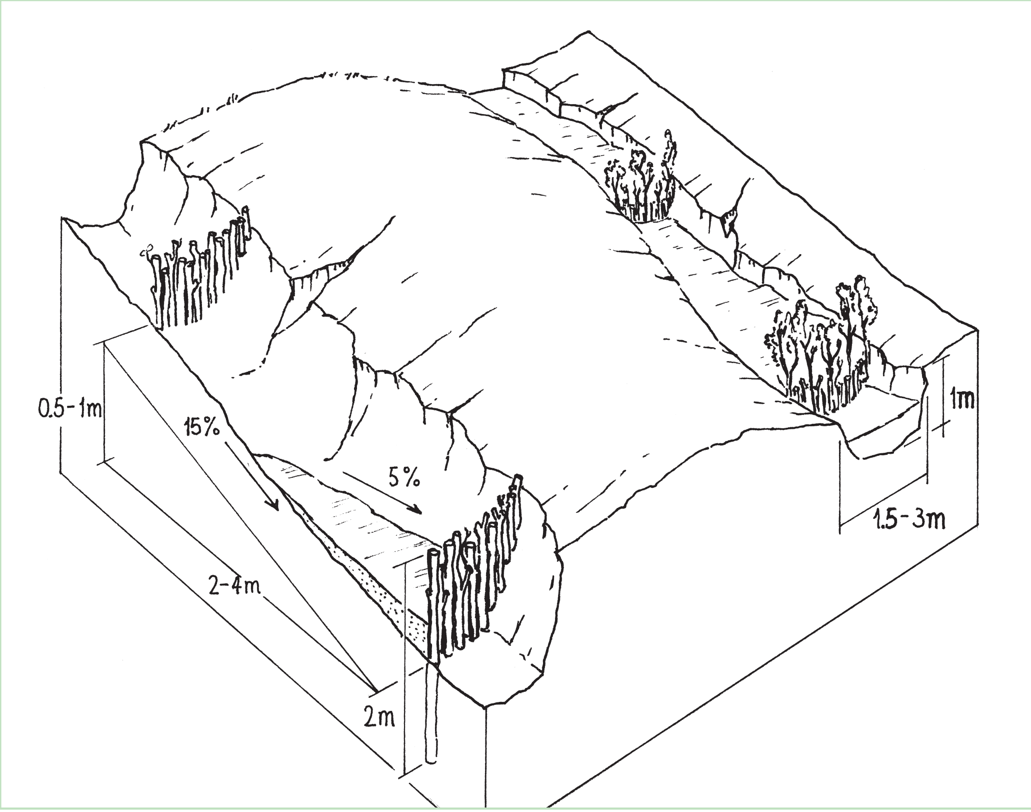
NB: soil properties before SWC

Growing season: 100 days (May to August) and 60–90 days (September to November)
Soil fertility: low
Soil texture: mainly fine (clay), some medium (loam)
Surface stoniness: abundant loose stone
Topsoil organic matter: low (<1%)
Soil drainage: good
Soil erodibility: high on slopes, low on plains (volcanic soils)

Human environment

Cropland per household (ha)

Land use rights: mainly individual, some leased
Land ownership: individual not titled, some individual titled
Market orientation: cropland: mainly subsistence (self-supply), some mixed (subsistence and commercial)
Level of technical knowledge required: field staff/extension worker: low, land user: moderate
Importance of off-farm income: 10–50% of all income: temporary or permanent migration, particularly young people



Technical drawing
Stem cuttings planted in gullies to form living check dams: recently planted (left) and cuttings that have begun to take root and sprout, resulting in the gully becoming filled with trapped sediment (right).

Implementation activities, inputs and costs

Establishment activities

1. Calculate and mark spacing between structures.
2. Cut poles out of selected local trees (diameter: 5–15 cm, length: 1.5–2.5 m depending on gully depth).
3. Dig small semi-circular ditches at the gully bottom (the depth of the ditch is half the length of the cuttings).
4. Plant the cuttings vertically into the ditch; put the thicker cuttings in the middle of the gully where runoff velocity is higher.
5. Fill ditch with excavated earth to fix the cuttings.
6. Water to encourage rooting.

Establishment activities carried out before rainy season (April/May).
Tools: 'line-level', tape measure, axe, machete, shovel, hoe.
Duration of establishment: 1–2 months

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour (50 person days)	100	100%
Equipment		
- Wheelbarrow	10	100%
- Tools	20	0%
Materials		
- Wood (300–500 poles)	60	100%
TOTAL	**190**	**90%**

Maintenance/recurrent activities

1. Biotrampas: pruning the trees every three years.
2. Cut-off drains: clearing of sediment, cutting bushes and grasses.
3. Stone check dams: pruning trees and bushes every three years. After full sedimentation, the dam may be increased in height.
4. Wooden check dams: pruning trees and bushes every three years.

All the maintenance activities can be made without machinery and require little labour and low-tech equipment.

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Labour (15 person days)	30	100%
Equipment		
- Tools	0	
Materials		
- Wood (<50 poles)	5	100%
TOTAL	**35**	**100%**

Remarks: Costs are calculated for a 100 m long, 2 m wide and 1 m deep gully with check dams every 4 m, on the basis of one gully per hectare. The wood (for poles) belongs to the land users themselves, thus the 'cost' does not involve purchase.

Assessment

Acceptance/adoption

- 30% of all farmers approached by the project (about 400 out of 1,200 land users) have built these check dams.
- 66% of those farmers accepted the technology with incentives; the remainder (34%) adopted check dams spontaneously without receiving any incentives other than training/technical assistance.
- Seeds, tools and credits were provided as incentives; the reasons for implementation included both the attraction of the incentives and perceived ecological benefits in terms of rehabilitation of degraded areas.
- There is a strong trend towards growing spontaneous adoption.
- Maintenance has been good.

Benefits/costs according to land user

Benefits compared with costs	short-term:	long-term:
establishment	negative	positive
maintenance/recurrent	neutral	very positive

Impacts of the technology

Production and socio-economic benefits

- ++ crop yield increase (where gullies planted)
- + fodder production (eg *madero negro = Gliricidium sepium)*
- + wood production increase (medium term)
- + farm income increase

Production and socio-economic disadvantages

- − labour constraints during establishment phase

Socio-cultural benefits

- +++ improves relationships between land users
- +++ improved knowledge SWC/erosion
- + community institution strengthening

Socio-cultural disadvantages

none

Ecological benefits

- +++ increase in soil moisture
- +++ soil loss reduction
- ++ increase in soil fertility

Ecological disadvantages

none

Off-site benefits

- +++ reduced downstream siltation
- ++ reduced downstream flooding
- + reduced river pollution

Off-site disadvantages

none

Concluding statements

Strengths and ➜ how to sustain/improve	Weaknesses and ➜ how to overcome
Facilitated land management: area is no longer divided by gullies ➜ Continue to construct and maintain.	The check dams used alone as SWC measure may not be adequate to withstand concentrated runoff ➜ It is important to combine this technology with other SWC practices (eg retention ditches on slopes at both sides of gully, live fences, etc).
Retards runoff speed: decreases erosion ➜ Ditto.	Only likely to be applied where land use rights are guaranteed.
Accumulation of fertile earth above the check dams, possibility of growing crops on 'terraces' between the structures ➜ Ditto.	Labour intensive.
Increased soil moisture ➜ Ditto.	

Key reference(s): Gurdiel G (1993) *La construcción de diques.* Tierra Fresca, Simas-Enlace, Managua ■ PASOLAC (2000) *Guía Técnica de Conservación de Suelos y Agua.* PASOLAC, Managua ■ LUPE (1994) *Manual Práctico de Manejo de Suelos en Laderas.* Secretaría de Recursos Naturales, Tegucigalpa, Honduras

Contact person(s): Roger Rodriguez, PASOLAC, Apartado Postal No.6024, Managua, Nicaragua; pasolac@cablenet.com.ni; phone/fax: (505) 277-1175, 277-0451, 277-0850 ■ Reinerio Mongalo, *Asociación Tierra y Vida* (AT&V), Nicaragua; tvida@ibw.com.ni

left: Catchment gully control combines a variety of different SWC measures: the steep small gullies are protected by a series of wooden check dams, 8–12 m apart, whereas the larger gully (bottom right) is stabilised by stone check dams. After sedimentation, bushes and small trees will be planted. (Georg Heim)
right: Stabilisation of degraded hillsides: *biotrampas* are simple wooden barriers, with a staggered layout, which trap eroded sediment and create suitable sites for tree planting. (PROMIC)

Gully control and catchment protection

Bolivia – *Control de cárcavas*

Integrated gully treatment consisting of several simple practices including stone and wooden check dams, cut-off drains and reforestation in sediment traps (biotrampas).

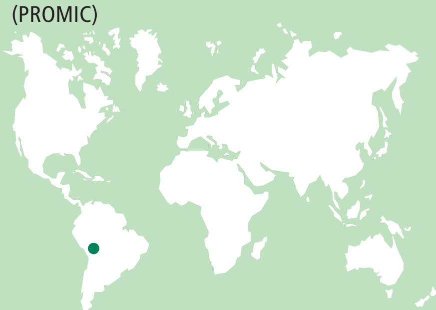
The focus of the case study is a degraded catchment, located at high altitude (2,800–4,200 m a.s.l.), home to 37 households, which is characterised by severe gullies and landslides. Gullies are continuously expanding, and constitute a significant proportion of the catchment. These cause considerable loss of cropland as well as downstream damage to the city of Cochabamba.

A combination of structural and vegetative measures was designed and implemented with the purpose of: (1) preventing affected areas from further degradation by safely discharging runoff from the surrounding area through the main gullies down to the valley; (2) gradually stabilising the land through the regeneration of vegetative cover; (3) reducing downstream damage through floods and siltation; (4) ensuring accessibility to the mountainous agricultural area during the rainy season.

Cut-off drains at the heads of the gullies, reinforced with stones inside the channel and grassed bunds below, concentrate runoff and cascade it down over stone steps back into the waterways. Flow is controlled by stone and wooden check dams and discharged safely. Sediment is trapped behind these structures and terraces develop. Bushes or trees are planted above and below the check dams. Depending on availability of materials, wooden check dams are sometimes used and associated with tree planting (four trees above and four below each check dam).

These practices are complemented by SWC measures throughout the catchment: *biotrampas* are staggered sediment traps located on the steep lateral slopes. They comprise ditches behind wooden barriers where soil accumulates. *Biotrampas* create suitable sites for tree/bush planting while stabilising the hillsides, reducing erosion, increasing infiltration and slowing siltation of the check dams in the watercourses. Supporting technologies include fenced-off areas for reforestation of the lateral slopes/upper edge of the gully, and finally large gabion dams at the outlets of the gullies, usually 10–25 m in length, but exceptionally up to 200 m.

After a few years vegetation should have stabilised the system, and effectively replaced the wooden and stone constructions. The various practices enhance each other. Establishment is labour demanding, but other costs are low, as long as the material in question is locally obtainable. Maintenance costs are also low. The technology was implemented over a period of six years, starting in 1996, through the Programa de *Manejo Integral de Cuencas* (PROMIC).



Location: Pajcha Watershed, Cordillera del Tunari, Cochabamba District, Bolivia
Technology area: 6 km^2
SWC measure: structural and vegetative
Land use: cropland and grazing land
Climate: semi-arid, subhumid
WOCAT database reference: QT BOL04 (combination); QT BOL05–09 (single components)
Related approach: Incentive-based catchment treatment, QA BOL02
Compiled by: Georg Heim, Langnau, Switzerland & Ivan Vargas, Cochabamba, Bolivia
Date: September 2003, updated June 2004

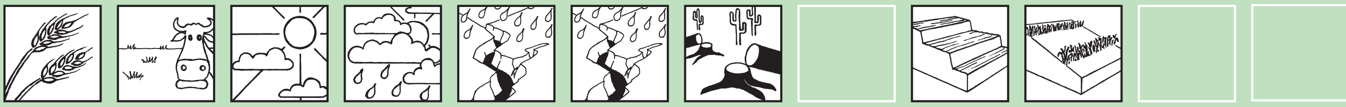
Editors' comments: Negative impacts of gullies may be felt on-site, but downstream also – as is the situation here. This case presents a combination of different technologies which enhance each others' impact. They are arranged systematically from the upper part of the catchment to the outlet of the gully. The overall cost is relatively low.

Classification

Land use problems

Deforestation, overgrazing and poorly managed channel irrigation in areas with steep slopes: poorly structured soils and extreme climatic variability causing erosion gullies, landslides, downstream flooding and sedimentation of agricultural land and settlements – including the city of Cochabamba.

Land use | **Climate** | **Degradation** | **SWC measures**



annual crops | extensive grazing | semi-arid | subhumid | water erosion: gully, landslides | offsite: down-stream flooding, deposition of sediments | vegetation: quantity decline (overgrazing) | structural: cut-off drains, sediment traps, dams | vegetative: aligned trees, grassed bunds

Technical function/impact

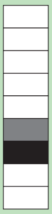
main:
- control of concentrated runoff
- reduction of slope angle
- reduction of slope length
- sediment harvesting
- improvement of ground cover
- increase in organic matter

secondary:
- control of dispersed runoff
- increase of infiltration

Environment

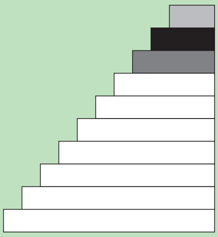
Natural environment*

Average annual rainfall (mm)



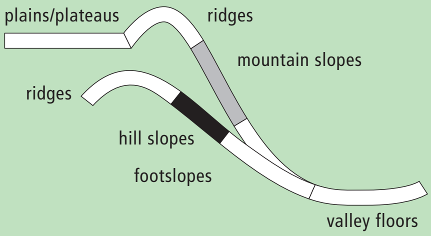
>4000
3000–4000
2000–3000
1500–2000
1000–1500
750–1000
500–750
250–500
<250

Altitude (m a.s.l.)

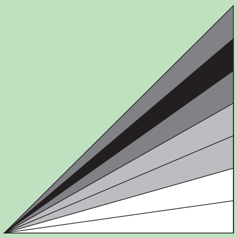


>4000
3500–4000
3000–3500
2500–3000
2000–2500
1500–2000
1000–1500
500–1000
100–500
<100

Landform

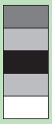


Slope (%)



very steep (>60)
steep (30–60)
hilly (16–30)
rolling (8–16)
moderate (5–8)
gentle (2–5)
flat (0–2)

Soil depth (cm)



0–20
20–50
50–80
80–120
>120

Growing season: 210 days (October to April)
Soil fertility: low to very low
Soil texture: medium (loam)
Surface stoniness: abundant loose stone
Topsoil organic matter: low (<1%) in the gullies and high (>3%)on the cropland at high altitudes
Soil drainage: medium
Soil erodibility: high to very high

NB: soil properties before SWC

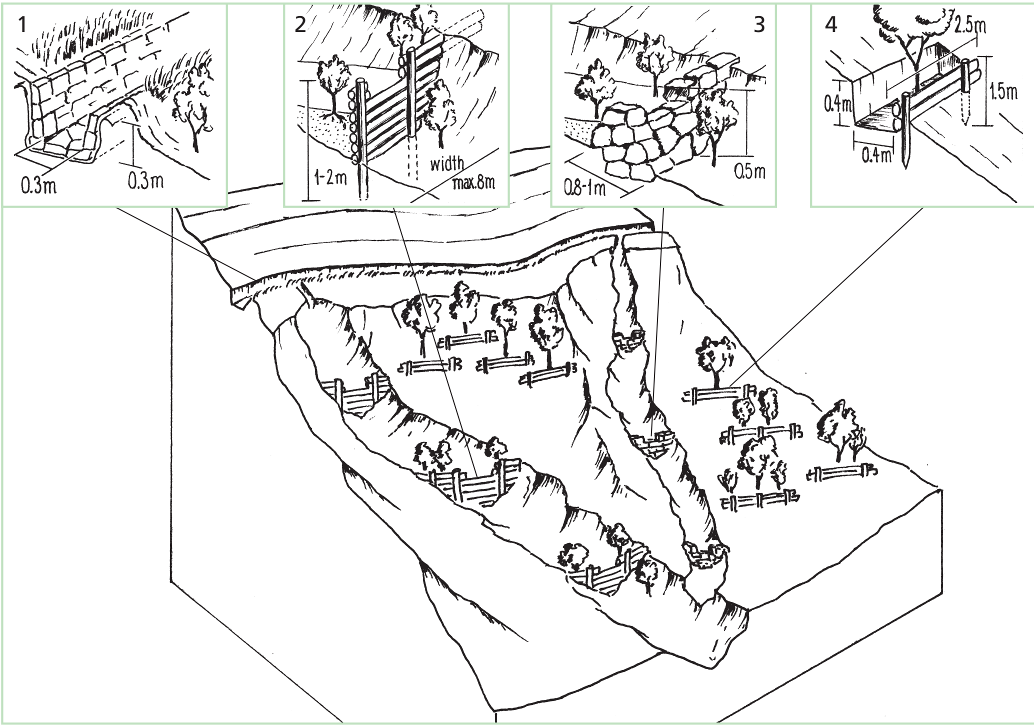
* Heterogeneous natural environment (eg regarding climate) due to altitude range

Human environment

Cropland per household (ha)

<1
1–2
2–5
5–15
15–50
50–100
100–500
500–1000
1000–10000
>10000

Land use rights: individual with organised communal grassland
Land ownership: individual titled and areas with communal grassland
Market orientation: mostly subsistence (self-supply) with low market income
Level of technical knowledge required: field staff/extension worker: moderate, land user: moderate
Importance of off-farm income: 10–50% of all income



Technical drawing:
Gully control and catchment protection: an overview of the integrated measures.
Insert 1: Stone-lined cut-off drain with grass-covered bund and live barriers.
Insert 2: Wooden check dam: note that trees are established to further stabilise the gully (as for stone check dams).
Insert 3: Stone check dam.
Insert 4: *Biotrampa:* staggered structures which collect moisture and sediment for tree planting.

Implementation activities, inputs and costs

Establishment activities

- Cut-off drains: excavate channel above the gully. Lay stones in the bed and plant local bushes or grass on the bund below the ditch. The outlet of the ditch into the gully is stabilised by a few stone steps.
- Stone check dams: excavate a ditch perpendicular to the water channel during the dry season for a foundation. Build a dam wall with stones (length 2–3 m, width 0.8–1.0 m, height 0.5–1.0 m).
- Wooden check dams (up to 8 m long, 15–20 cm wide and 1 m high): soil excavation (see 2.). Fix logs with wire or nails to vertical poles. Position a bio-fibre fleece behind the dam to prevent sediment from flowing through.
- *Biotrampas:* excavate soil, hammer wooden posts into the soil and fix 2–3 horizontal logs with nails or wire to the wooden posts. (During dry season).
- Plant local bushes and trees in front and behind the *biotrampas* and the check dams (after sedimentation). Altitude acclimatisation (2 weeks) is required for the trees before planting.
- Establish fences to protect the plants.

Duration of establishment: not specified

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour (12 person days)	48	0%
Equipment		
- Tools	4	0%
Materials		
- Stone (56 m^3)	0	
- Wood (5 m^3)	33	0%
- Nails, wire, etc	2	0%
- Bio-fibre fleece	4	0%
Agricultural		
- Seedlings	19	0%
TOTAL	**110**	**0%**

Maintenance/recurrent activities

1. Biotrampas: pruning the trees every three years.
2. Cut-off drains: clearing of sediment, cutting bushes and grasses.
3. Stone check dams: pruning trees and bushes every three years. After full sedimentation, the dam may be increased in height.
4. Wooden check dams: pruning trees and bushes every three years.

All the maintenance activities can be made without machinery and require little labour and low-tech equipment.

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Labour (3 person days)	12	100%
Equipment		
- Tools	1	100%
Materials		
- Stone (0.5 m^3)	0	
- Wood (0.04 m^3)	1	100%
- Nails, wire, etc	1	100%
Agricultural		
- Seedlings	1	100%
TOTAL	**16**	**100%**

Remarks: Costs have been calculated for the whole catchment (6 km^2) – including 100 m of cut-off drains, 6,750 m of stone check dams, 1,500 m of wooden check dams and 770 *biotrampas* – and then divided by the number of hectares. Wood is not locally available (because of national park laws) and needs to be brought into the area. Establishment and maintenance costs were paid by PROMIC during their intervention period of 6 years. The (high) costs of the gabion weirs further downstream are not included as these are not always required and vary considerably in size from site to site.

Assessment

Acceptance/adoption

During the project phase, all the farmers who implemented the technology did it with incentives (cash-for-work). Farmers initially maintained the structures because of PROMIC subsidies, and post-project, partially because of the benefits. However, only a few of them have built new structures post-project. This is due to different reasons: (1) PROMIC stopped its financial support; (2) the gullied areas are not used by farmers, therefore they have little reason to protect them; (3) the catchment is within a national park – and trees are protected, which means that wood for *biotrampas* construction is not available locally; (4) insufficient sensitisation regarding effects of erosion and SWC measures in the area.

Benefits/costs according to land use

Benefits compared with costs	short-term:	long-term:
establishment	very positive	very positive
maintenance/recurrent	very positive	very positive

Impacts of the technology

Production and socio-economic benefits

| + | | | maintained crop and fodder production due to prevention of further land loss |

Production and socio-economic disadvantages

| – | – | | high labour input for establishment (though paid in this instance) |

Socio-cultural benefits

| + | + | + | improved knowledge SWC/erosion |
| + | | | community institution strengthening |

Socio-cultural disadvantages

| – | – | – | farmers implementing SWC are not those benefiting most from the impact in the short term |

Ecological benefits

+	+	+	soil loss reduction
+	+		soil cover improvement
+			increase in soil moisture

Ecological disadvantages

none

Off-site benefits

| + | + | + | reduced downstream flooding |
| + | + | + | reduced downstream siltation |

Off-site disadvantages

none

Concluding statements

Strengths and ➜ how to sustain/improve

Reduction of landslips and flooding in the valley ➜ New small gullies may originate inside an existing gully or around it. It is important to continue to maintain the current measures and construct new, even though the subsidies of PROMIC have been terminated.

The technology could be implemented by the farmers themselves as materials (except for wood) and tools are locally available ➜ Prolong the sensitisation work to convince the farmers of the necessity and benefits of the technology.

Reduction of soil loss in the watershed ➜ Do not apply the mentioned practices in isolation but always in combination.

Simple technology with high positive long-term impact, especially downstream.

Weaknesses and ➜ how to overcome

The technology doesn't address the root cause of human induced gully erosion ➜ Alongside the gully control technology it is necessary to apply complementary conservation measures on the cropland above the gully to prevent new gully development.

High labour input for establishment of SWC measures.

The technology partly depends on inputs that are not available locally: timber for establishment of wooden structures (which is a significant quantity) are brought in from outside (since the area is within a national park tree felling is not allowed) ➜ An agreement on sustainable use of trees should be made with the national park authority.

Key reference(s): Documentation of PROMIC (see address below)

Contact person(s): Georg Heim, Mooseggstrasse 9, 3550 Langnau, Switzerland; geoheim@bluewin.ch ▪ PROMIC, *Programa de Manejo Integral de Cuencas,* Av. Atahuallpa final, Parque Tunari, casilla 4909, Cochabamba, Bolivia; promic@promic-bolivia.org; www.promic-bolivia.org

left: Individual planning (at farmer level) of activities to treat the large gully in the background: a PROMIC engineer and local people are involved. Note the city of Cochabamba in the distance. (Georg Heim)
right: The approach focuses on the regeneration and stabilisation of seriously degraded catchments by a combined package of structural and vegetative measures. (Georg Heim)

Incentive-based catchment treatment

Bolivia – *Manejo de áreas degradadas*

A project supported, incentive-based approach: farmers are sensitised about erosion, and involved in gully control and other measures to protect catchments.

The objective of the locally-based organisation *Programa de Manejo Integral de Cuencas* (PROMIC) is to involve land users in the control of soil erosion in the catchments above Cochabamba city. While erosion here is largely a natural process, it is aggravated by inappropriate agricultural practices. PROMIC receives funds from national and international governments, and works in an interactive manner. Together with local farmers, erosion processes in the context of the human environment were analysed to identify the needs of the agriculture population - and to plan a conservation and development programme. The aim was to convince farmers of the necessity to protect their agricultural land and stabilise the gullies below, and of the overall importance of implementing technologies to combat erosion.

The farmers were involved in the process through regular community meetings organised by PROMIC, in which they could adjust PROMIC's catchment intervention plans to their own requirements through an interactive process. PROMIC considered that the sensitisation work and the interactive process were essential to ensure long-term sustainable land use. In the short term, however, it will be mainly the city downstream – Cochabamba – that benefits from the implementation of the erosion control technologies. For that reason, the farmers were paid to carry out construction of the measures (through 'cash-for-work'). The farmers should, however, profit from the technologies in the long term. They were taught how to build and maintain check dams, cut-off drains and *biotrampas*. The implementation in the watershed started in 1996 and took six years: when the implementation phase was over, farmers no longer received financial subsidies. The long period of sensitisation should help to ensure that farmers incorporate erosion prevention technologies into their cropland above the gullies.

PROMIC still monitors the state of the structures from time to time, but most of the maintenance is left to the farmers themselves. PROMIC continues, however, to provide technical support and some transport of materials. Both internal and external evaluation followed the end of the implementation phase.

Location: Pajcha Watershed, Cordillera del Tunari, Cochabamba district, Bolivia
Approach area: 6 km^2
Land use: cropland and grazing land
Climate: semi-arid, subhumid
WOCAT database reference: QA BOL02
Related technology: Gully control and catchment protection, QT BOL04 (description of combined technology); QT BOL05, BOL06, BOL07, BOL08 and BOL09 (description of single components)
Compiled by: Georg Heim, Langnau, Switzerland & Ivan Vargas, Cochabamba, Bolivia
Date: September 2003, updated June 2004

Editors' comments: SWC projects aimed primarily at achieving downstream benefits are faced with the difficult problem of how to achieve participation when production benefits do not immediately accrue to the land users on-site. Incentives of some form need to be used – at least in the establishment phase. A future option may be for city dwellers to pay for 'environmental services' provided by land users in the hills above.

Problem, objectives and constraints

Problem

- lack of knowledge about damage caused by erosion and benefits of various possible conservation technologies
- lack of financial resources: shortage of funds prevents farmers investing in technologies, even if these bring benefits to them (as well as to the downstream population)
- persistence of detrimental traditional agricultural practices, leading to accelerated degradation

Objectives

- teach farmers about sustainable land use
- build up skills amongst farmers to enable them to treat gullies without outside help
- reduce flooding and sedimentation in the valley of Cochabamba and general soil loss in the area through collaboration with farmers in the watershed
- improve traditional agriculture with a package of conservation-related practices
- indirectly support farmers by cash-for-work incentives which enables them to implement SWC technologies on their own fields

Constraints addressed

Major	Specification	Treatment
Financial	Few direct short-term profits from SWC technologies in gullies for the farmers in the watershed (the main beneficiary is the city of Cochabamba downstream).	Search for national and international subsidies to help the farmers to implement the technologies during the initial period.
Climate	Climatic extremes such as strong winds and excess or deficit of rain.	Plant trees at close spacing, and plant trees/ shrubs that can tolerate climatic extremes.
Minor	**Specification**	**Treatment**
Institutional	The local farmers' association is insufficiently organised to ensure the independent continuation of activities post-project.	Local farmers' association should be included in the sensitisation and implementation process.
Policy	The local administration/government doesn't subsidise and support SWC, except for a minor financial contribution to PROMIC.	Enhance awareness in the downstream city of Cochabamba to ensure policy and financial contributions from the city to the gully control technologies upstream: in other words payment for environmental services.
Policy	The location of the watershed in the National Park of Tunari means the farmers cannot cut wood for building structures.	Wood required has to be brought into the area from outside the park (this was paid for by the project).

Participation and decision making

Target groups

Land users/
local farmers
association

Approach costs met by:

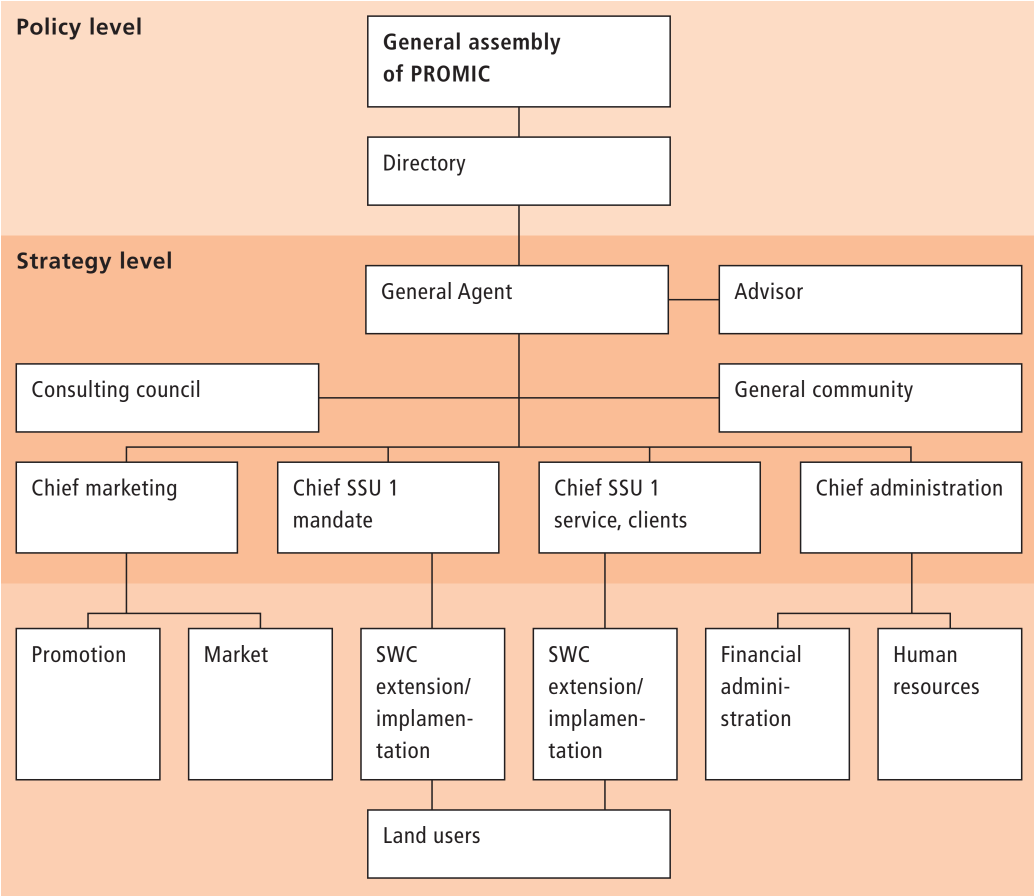
International agency	80%
National government	20%
	100%

Decisions on choice of the technology: Made by specialised engineers of PROMIC; farmers were involved by modifying initially proposed technologies.
Decisions on method of implementing the technology: Made by specialised engineers of PROMIC.
Approach designed by: National specialists with national university collaboration.

Community involvement

Phase	Involvement	Activities
Initiation	passive	interviews, information during regular meetings
Planning	interactive	results of the socio-economic diagnosis defined the planning; farmers were involved through regular meetings: interactive planning at individual and community level
Implementation	payment/incentives	all farmers had the opportunity to collaborate through paid labour
Monitoring/evaluation	passive	internal and external evaluations where farmers were interviewed
Research	passive	socio-economic diagnosis; collection and analysis of bio-physical baseline data

Differences in participation between men and women: There were no women working in the gully rehabilitation. The reason is a cultural taboo against women working with heavy materials; women are responsible for looking after cattle, and for the household.



Organogram
- General assembly: National and international public and private institutions, members, foundation
- Directory: Prefecture, general agent, Swiss Agency for Development and Cooperation (SDC), Belgian Technical Cooperation (BTC), private enterpreneurs
- Consulting council: Municipalities, projects, universities
- Advisors: General agent, marketing, SSU1, SSU2 (see below), administration
- SSU: Strategic service unit
- Services: Executive body for technology extension and implementation: PROMIC field technicians

Extension and promotion

Training: The approach included training on technical aspects and on long-term planning for sustainable land use. Some farmers were trained to become foremen – who in turn instructed other farmers. During the construction period PROMIC project staff trained farmers on the job in soil conservation practices. The visits of PROMIC project staff to individual farmer-families turned out to be the most effective method.
Extension: PROMIC carried out participatory planning of gully treatment: this included making farmers aware of the environmental and economic necessity for the technology. There was interactive planning of technology implementation at individual and community levels.
Research: Research was an important part of the approach, not only for planning (based on biophysical and socio-economic data), but also to stay in contact with the rural population and to obtain their confidence. Thanks to the research, the technology is well adapted to the biophysical conditions. Research topics included SWC (testing different measures), various soil parameters and a socio-economic survey.
Importance of land use rights: The gullied area is mainly common land in terms of use and ownership, but the fields above the gullies are mostly privately owned. At the beginning this played an important role, as the farmers were afraid to lose their land rights (due to bad experiences previously with similar projects). However, they collaborated during the implementation phase, as they recognised the programme's objectives and realised that there could be potential benefits for their own land, as well.

Incentives

Labour: 100% of the implementation was subsidised. Farmers were contracted to build the structures.
Inputs: Beside the labour for the rehabilitation of the gully area, PROMIC also paid for machinery, hand tools, transport of materials, seedlings and community infrastructure (roads). PROMIC also provided technical support and transport for further technology implementation on individual crop fields.
Credit: There was no credit facility for farmers.
Support to local institutions: Moderate training support for the local farmers' association was provided in terms of improvement of the association's organisation and reinforcement of their influence.
Long-term impact of incentives: Farmers now rarely treat any more gullies without payment – which implies a negative long-term impact. On the other hand, the incentives given (payment for construction work in the gullies) has had a positive short-term impact: the farmers now have more money for tools for soil conservation measures on their own cropland.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	ad hoc measurements of erosion rate
Technical	regular observations (photo monitoring)
Socio-cultural	ad hoc interviews and visits
Economic/production	ad hoc interviews
Area treated	regular observation (visits and photo monitoring)
No. of land users involved	ad hoc surveys
Management of approach	ad hoc observations (external evaluation of impact)

Impacts of the approach

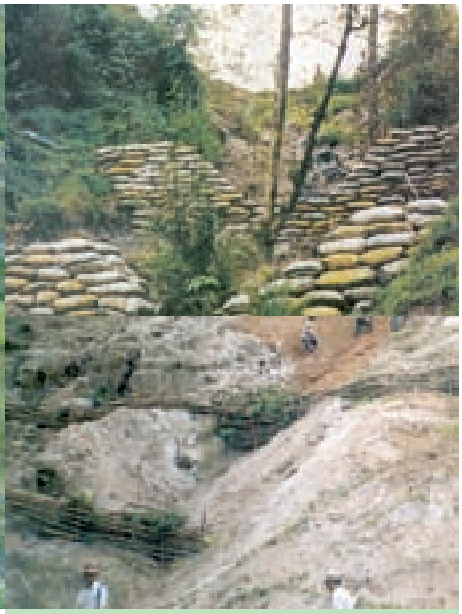
Changes as result of monitoring and evaluation: The approach was to initially target groups. Later, individuals were included (with individual farmer-family visits) to improve the effectiveness of the awareness raising and the implementation.
Improved soil and water management: The approach resulted in a considerable improvement in SWC. However, despite new knowledge about erosion, the farmers themselves hardly carry out any new gully conservation work without payment, and in the long term maintenance is not ensured.
Adoption of the approach by other projects/land users: Some other projects in Bolivia have copied parts of PROMIC's approach.
Sustainability: There is enough technical knowledge to continue with soil conservation in gullies. However the supportive technology of gabion dams (see related technology) can't be carried out by the farmers themselves, as there is a very high level of engineering knowledge and skill required. The other practices, such as stone and wooden check dams, cut-off drains and reforestation can be implemented by the farmers themselves. The problem is that off-site advantages outweigh the on-site benefits considerably. To achieve more long-term adoption by the farmers, the programme needs more time than just six years. Only a few farmers are able and willing to apply long-term sustainable land management in the gullies.

Concluding statements

Strengths and ➜ how to sustain/improve
Integration of farmers in the process of implementation of soil conservation ➜ Farmers need to be even more integrated in the process of monitoring to guarantee the maintenance of the soil conservation achieved.
Transparent process during research, planning and implementation phases; incorporation of farmers' ideas (thus: good acceptance of PROMIC by the rural population).
Sensitisation of the farmers to erosion and degradation processes, and awareness creation about the impact and necessity of SWC in the hills to protect the valleys ➜ Continued sensitisation work after the implementation phase.
Good technical support during and after conclusion of the implementation phase ➜ Technical support not enough on its own – needs to be complemented by further sensitisation.

Weaknesses and ➜ how to overcome
Sensitisation phase (for farmers and government) was too short to ensure sustained application of the technology without external support and supply. Established structures are often neglected and thus deteriorate ➜ Find new donors to continue the training/awareness raising on SWC technologies. Include the farmers in the monitoring visits and demonstrate examples of successful SWC (positive stimuli).
Lack of money for replication and long-term maintenance of SWC measures ➜ Guarantee financial support in the threatened area, by the local government and international organisations.
Farmers implementing SWC are not those benefiting most from the impact in the short term; even though the city of Cochabamba benefits considerably, financial support for implementation has stopped ➜ Seek financial support from Cochabamba; implement a system of payment for 'environmental services'

Key reference(s): PROMIC documentation (see address below)
Contact person(s): Georg Heim, Mooseggstrasse 9, 3550 Langnau, Switzerland; geoheim@bluewin.ch ■ PROMIC, *Programa de Manejo Integral de Cuencas,* Av. Atahuallpa final, Parque Tunari, casilla 4909, Cochabamba, Bolivia; promic@promic-bolivia.org; www.promic-bolivia.org



left: Area three years after treatment (left of picture) and adjacent untreated area affected by steam bank erosion and land slips (right of picture). (Hanspeter Liniger)
right: Check dams made from cement bags filled with a mixture of sand, earth, cement and brick chips at Indrayani, Gagalphedi, Kathmandu District (top). Woven bamboo fences positioned in gullies near the Bajrayogrini Temple, Kathmandu District (bottom). Both sites are similar to the case study area. (P Mathema and I B Malla, respectively)

Landslip and stream bank stabilisation

Nepal – *Bans ko atta / Manra bandhi*

Integration of vegetative and structural measures for landslip, stream bank and gully stabilisation on hillsides.

A combination of measures, implemented by a group of neighbouring families, is used to address landslips, gully formation and stream bank erosion problems in the middle hills of Nepal. All these processes affect the stability of adjacent agricultural land and cause problems downstream. Small-scale farming is dominant in the area surrounding the treated land – which theoretically belongs to the government but is used by these families.

This pilot technological package is proving suitable in Nepal for steep/very steep slopes under subhumid climates within an altitudinal range of 1,000–1,500 m a.s.l. This type of intervention, combined with the active involvement of stakeholders (who contribute three quarters of the cost), was recently introduced to Nepal under a watershed management programme, co-funded by the European Commission (see related approach 'Integrated watershed management').

Initially, ditches with bunds on the lower side are constructed along the contour. Within the gullies and along the stream banks, cement bags (filled with cement, brick chips, sand and/or earth) are placed to avoid deepening of the channel. Wattle fences, made from woven bamboo are also used as checks in the gullies. These structures are complemented by vegetative measures: Nepalese alder *(Alnus nepalensis),* bamboo *(Dendrocalamus sp.),* cardamom *(Elettaria cardamomum),* and broom grass *(Thysanolaena maxima)* are planted. These species establish quickly in degraded sites and also control erosion, stabilise land and serve as cash crops, and for fodder, fuelwood and timber. Alder (locally called *utis)* is a nitrogen-fixing multipurpose tree which helps restore soil fertility.

Farmers can get economic benefits within a few years from these plants. Another advantage of this package is that the vegetative resources needed are locally available and cheap. Furthermore farmers already know how to propagate them. Maintenance costs are negligible. Once established, the stabilised and revegetated sites provide improved environments for birds and insects – thus favouring biodiversity – and they help protect natural springs. In this case study, the economic returns from the cash crops mainly go to one family. Another few families also utilise this site, extracting common products (fodder, litter, timber) for domestic use. Additionally, the location is regularly used as an unofficial demonstration site, being visited by various people (farmers, SWC specialists) interested in the technology. This represents an indirect benefit to a larger number of people and strengthens institutions at household and community levels.

Location: Sakhintar, Kathmandu/Bagmati watershed, Kathmandu, Nepal
Technology area: 0.14 km^2
SWC measure: structural and vegetative
Land use: wasteland (before), mixed: agro-silvopastoral (after)
Climate: subhumid
WOCAT database reference: QT NEP11
Related approach: Integrated watershed management, QA NEP11
Compiled by: Dileep K. Karna, Department of Soil Conservation and Watershed Management, District Conservation Office, Kathmandu, Nepal
Date: February 2003, updated August 2004

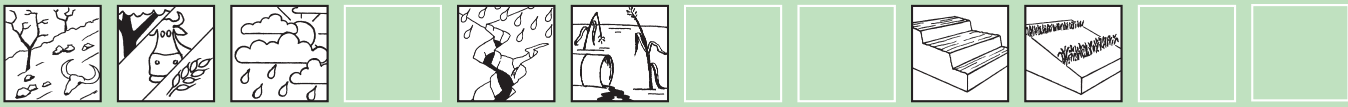
Editors' comments: This promising technology, new to Nepal, comprises a set of vegetative and structural measures for stabilisation of land where streams are cutting back into fields, or subsurface runoff causes landslips. Income is generated from various plants. The technology focuses on a problem common to the tropical/sub-tropical steeplands, and could be widely applicable both in Nepal and elsewhere.

Classification

Land use problems

- concentrated runoff from upstream agricultural areas
- landslides, gullies and stream bank erosion
- gullies backcutting into fertile agricultural land and also threatening irrigation canals and homesteads.

Land use **Climate** **Degradation** **SWC measures**



wasteland: degraded shrub-land (before); agro-silvopastoralism (after); subhumid; water erosion: gully, mass movement, river-bank erosion; chemical: fertility decline; structural: ditches/bunds, cement bags, wattle fences; vegetative: tree/shrub cover, grasses (dispersed/aligned)

Technical function/impact

main:
- impede/retard concentrated runoff
- improvement of ground cover
- stabilisation of soil
- reduction of slope angle
- reduction of slope length

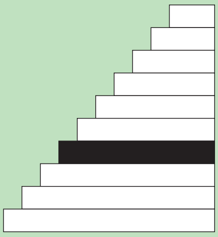
secondary:
- drain/divert concentrated runoff
- increase infiltration (due to improved ground cover)

Environment

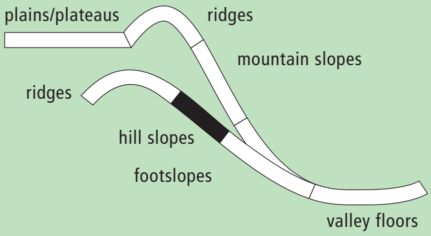
Natural environment

Average annual rainfall (mm)

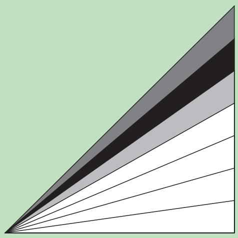
Altitude (m a.s.l.)



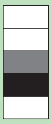
Landform



Slope (%)



Soil depth (cm)



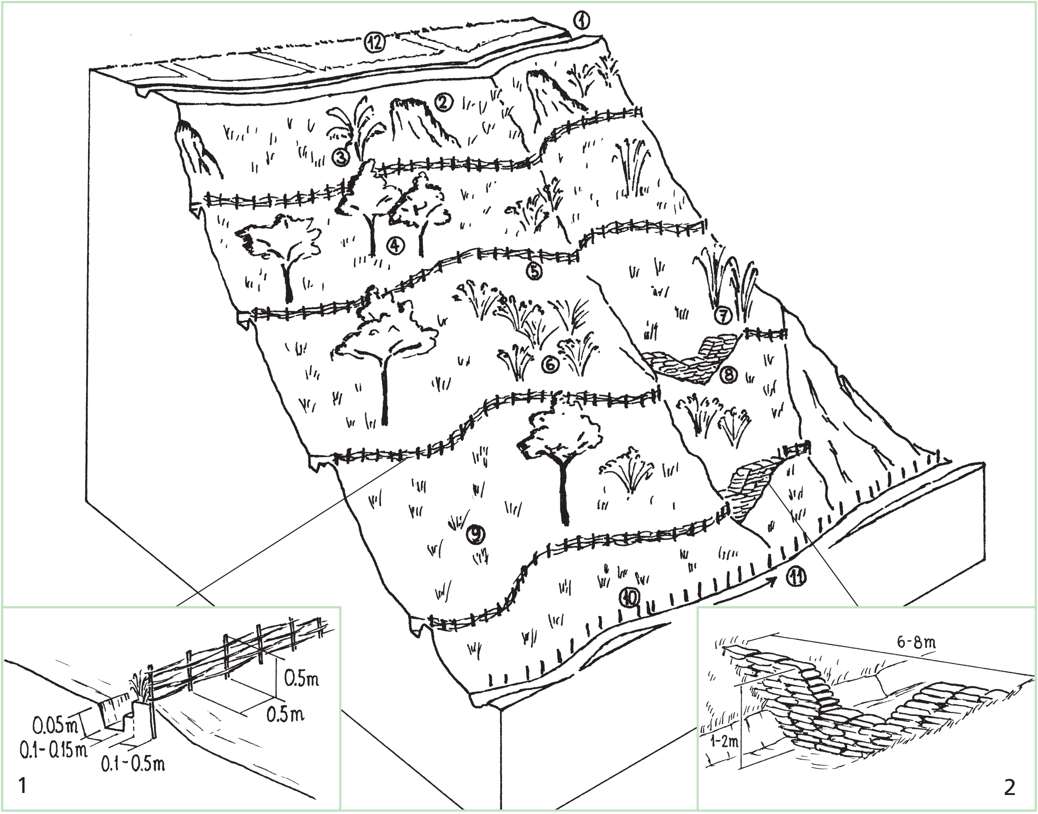
NB: soil properties before SWC

Growing season: 180 days (June–November), on surrounding irrigated areas crops are grown the whole year round
Soil fertility: mostly high, partly medium
Soil texture: mostly medium (loam), partly coarse (sandy)
Surface stoniness: no loose stone
Topsoil organic matter: medium (1–3%)
Soil drainage: medium
Soil erodibility: high

Human environment

Mixed land per household (ha)

Land use rights: open access
Land ownership: state
Market orientation: subsistence and mixed (subsistence and commercial)
Level of technical knowledge required: field staff/extension worker: high during establishment period, low to moderate during maintenance; land user: high for establishment, moderate to high during maintenance
Importance of off-farm income: <10% of all income: occasionally teaching at farmers' school; selling non-timber forest products in the local market; some people work in markets/shops/ on construction sites etc



Technical Drawing
Landslip and stream bank protection: an overview of the multiple and integrated vegetative and structural measures: cut-off drain (1); land slip area (2); banana trees (3); alder trees (4); bamboo wattle fences (5); cardamom (6); bamboo planting (7); cement bag check dams (8); broom grass (9); bamboo cuttings (10); stream bank (11), agricultural fields in a flat area (12).
Insert 1: Bamboo wattle fence combined with retention ditch and grassed bund to stabilise steep slopes and gullies.
Insert 2: Old cement bags filled to form checks in gullies.

Implementation activities, inputs and costs

Establishment activities

1. Construction of contour bunds and ditches (January–April).
2. Stabilisation of slopes and gullies using bamboo wattle fences
3. Gully stabilisation with walls of cement bags placed across the gullies and along the stream banks (June).
4. Preparing the site for planting (June).
5. Planting of alder *(Alnus nepalensis,)*, cardamom *(Elettaria cardamomum)*, bamboo *(Dendrocalamus sp.)* and broom grass *(Thyosonaelana maxima)* (July–August).
6. Watering of plants using buckets (March–May, 1st year).
7. Application of farmyard manure at time of planting, and every December.
8. Weeding (January).
9. Earthing up (January).

All activities carried out manually.
Tools: local and traditional tools, A-frame, digging axe, hoe, pipe, water pump, baskets, shovel, hammer.
Duration of establishment: 1 year

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour (1,560 person days)	2,115	75%
Equipment		
- Tools	55	100%
- Empty cement bags (600)	10	0%
Materials		
- Cement bags (30) filled with earth/other material (50 kg each)	125	0%
- Bamboo	0	
Agricultural		
- Seeds (Alder: 50 g)	0	
- Seedlings (400 large cardamom slips)	5	0%
- Alder: saplings (2,500/ha)	40	100%
- Bamboo cuttings (600)	565	50%
- Manure (1 t/ha)	10	100%
TOTAL	**2,925**	**68%**

Maintenance/recurrent activities

1. Application of farmyard manure (January).
2. Weeding (January).
3. Preparing land for further planting of large cardamom and broom grass (March–April)
4. Thinning of cardamom, bamboo, alder, broom grass with a knife: *churi marna* (May, June).
5. Replanting of cardamom, broom grass, bamboo (June, July).
6. Earthing up (August–September and January).
7. Pruning of alders (December, January).

All activities done annually and by manual labour, no additional tools (see establishment).

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Labour (40 person days)	55	100%
Equipment		
- Tools	10	100%
Agricultural		
- Plant material (various)		
- Manure (500 kg)	5	100%
TOTAL	**70**	**100%**

Remarks: Labour costs: information based on oral information by farmer. Estimate was approx. 3 people per working day over 2 years.

Assessment

Acceptance/adoption

The technology was piloted in the case study area, but in the meantime, other farmers have taken it up outside the location.

- 18 families (47%) took up the technology with incentives: partly paid labour, seedlings, bamboo culms and cement bags.
- 20 relatively well resourced families (53 %), spontaneously adopted the technology because of its economic benefits on marginal land. This is a growing trend.
- Land users have adequately maintained what has been implemented.

Benefits/costs according to land user

Benefits compared with costs	short-term:	long-term:
establishment	negative	very positive
maintenance/recurrent	positive	very positive

Impacts of the technology

Production and socio-economic benefits

- +++ fodder production/quality increase
- ++ wood production increase
- ++ farm income increase: cash crop introduction

Production and socio-economic disadvantages

- −−− increased labour constraints during establishment
- −−− increased input constraints for establishment
- − labour constraints during maintenance
- − increased input constraints for maintenance

Socio-cultural benefits

- +++ community institution strengthening in a broad sense (eg as a result of common establishment activities; visits to the site by outsiders)
- +++ improved knowledge SWC/erosion
- ++ improved health (due to cardamom's medicinal properties)
- ++ national institution strengthening

Socio-cultural disadvantages

- −− socio-cultural conflicts
- −− might encourage other people to illegally extract the non-timber forest products (because of remoteness)

Ecological benefits

- +++ soil cover improvement
- +++ soil loss reduction from approx. 200 t/ha/year down to 10 t/ha/year
- +++ stabilisation of slope
- ++ increase in soil fertility
- ++ increase in soil moisture
- ++ efficiency of excess water drainage
- ++ spring protection (increase of water quantity/more steady flow)
- + biodiversity enhancement

Ecological disadvantages

- −− increased soil erosion and sediment transport (locally) during establishment of structural measures

Off-site benefits

- +++ stabilisation of off-site agricultural land
- ++ reduced downstream siltation
- ++ reduced runoff/transported sediments
- + reduced river pollution
- + increased stream flow in dry season
- + reduced downstream flooding

Off-site disadvantages

- − grazing pressure increase elsewhere because of SWC site being closed for grazing

Concluding statements

Strengths and ➜ how to sustain/improve

The technology requires resources which are largely locally available and of low cost ➜ Raising awareness that landslide threatened stream banks and steep slopes can be stabilised using local resources.

Technology addresses livelihood constraints ➜ Raising awareness that the technology is profitable.

Family members have learnt the technology. It is easy to replicate ➜ Provide training and schooling to farmers to spread this information to others (eg through village initiatives supported by government).

Better environment, increased biodiversity ➜ Ditto.

Soil and water conservation ➜ Ditto.

Fresh products, health benefits from cardamom ➜ Ditto.

Income generation through cash crop introduction (cardamom, bamboo, broom grass) ➜ Ditto.

Weaknesses and ➜ how to overcome

Establishment costs are high ➜ Subsidise the cost (extension service, projects). Reduce establishment costs by designing alternative structural measures without use of cement.

Socio-economic conflicts can arise when value of land is raised ➜ Take equity issues into account when implementing such a programme, and spread the benefits.

Establishment is very labour intensive.

The technology is adopted more by better resourced farmers ➜ Government programmes should involve poor farmers in land development with incentives for adoption of demonstrated technology.

Key reference(s): Bagmati Integrated Watershed Management Programme (2003): *Engineering Field Manual.* His Majesty's Government of Nepal, Ministry of Forest and Soil Conservation, Department of Soil Conservation and Watershed Management. Kathmandu, Nepal ▪ Howell J (ed.) (1999): *Roadside Bio-engineering – reference manual.* Department of Roads, His Majesty's Government of Nepal

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left: On-site training for members of Salambudevi Community Forest User Group, Sankhu, Salambutar, organised by the Department of Soil Conservation and Watershed Management. (BIWMP)
right: Farmer with a mature cardamom plant: one of the vegetative measures which add a productive component to the landslip and streambank rehabilitation technology. (Hanspeter Liniger)

Integrated watershed management

Nepal – *Jan sahabhagita ma aadharit ekikrit jaladhar byabasthapan*

Integrated watershed management based on fostering a partnership between community institutions, line agencies, district authorities and consultants.

The Bagmati Integrated Watershed Management Programme (BIWMP) was based on fostering partnership among communities, district authorities, line agencies, and consultants. The main purpose was to ensure sustainable management of mountain watersheds. The means of addressing natural resource degradation problems were identified through participatory action research. These included options for better horticulture, agroforestry, irrigation, landslip stabilisation (see related technology), community forestry, vegetable cultivation, and wasteland development. The activities focussed on poverty reduction through sustained income generation, soil and water conservation in agriculture and forests, erosion hazard treatment and infrastructure improvement. All this took place in the context of equitable involvement of women and the socially disadvantaged with an emphasis on local ownership, institutional capacity building and sustainability.

The integrated watershed management programme included various participatory extension methods such as farmer-to-farmer exchange, training workshops and on-site demonstration. Under the programme, planning, implementation and monitoring of identified activities was done in a participatory manner. And the approach was deliberately flexible, adapting to new findings. Based on the priorities of the villagers, activities were implemented by individual households, farmers groups or village institutions.

BIWMP was initiated, coordinated and organised by the Department of Soil Conservation and Watershed Management (Ministry of Forest and Soil Conservation) with the active support of the European Commission. Within BIWMP there was cooperation with local institutions including VDCs (Village Development Committees), local NGOs (eg 'Friendship Sakhu', 'Helping Hands'), the CFUG (Community Forest User Group) – and individual households as in the case of the landslip and stream bank stabilisation initiate. It was considered essential that the approach would involve multiple stakeholders for SWC activities.

The first phase began implementation through user groups in 1986. In 1992 a European Commission mission evaluated the programme's activities and praised the technical packages, but suggested improvements to its implementation procedures, especially in terms of community organisation, extension, integration of activities and income generation activities. These were addressed in a second phase of the programme. Capacity building of community groups involved establishment of communication facilities, building up community networks, and empowering women and disadvantaged groups. BIWMP ended in 2003.

Location: Lalitpur, Kathmandu, Makwanpur, Bhaktapur, Sindhul; Bagmati river basin, Nepal.
Approach area: 570 km^2
Land use: wasteland (before), mixed: agro-silvopastoral (after)
Climatic regime: subhumid
WOCAT database reference: QA NEP11
Related technology: Landslip and stream bank stabilisation, QT NEP11
Compiled by: Dileep Kumar Karna, Department of Soil Conservation and Watershed Management, District Soil Conservation Office, Kathmandu, Nepal
Date: December 2003, updated August 2004

Editors' comments: Watershed management through people's participation is common in Nepal. However, projects differ in specific approaches and in the technologies promoted. What marks this project's approach as unique in Nepal is the emphasis on people's participation, simultaneously stimulated by direct benefits accruing to the community from conservation-friendly plants.

Problem, objectives and constraints

Problem
BIWMP addressed problems related to institutional capacity for managing watershed resources.

Objectives
The overall objective was to overcome the constraints of effective implementation of a watershed management programme, through building synergies within a diversity of institutions. In case of the landslip and stream bank stabilisation work the specific objective was to come up with a technology that conserved soil and water but also provided direct benefits to the community through production.

Constraints addressed

Major	Specification	Treatment
Institutional	Lack of inter-institutional collaboration.	Building and ensuring collaboration.
Technical	Lack of new options.	Training about new technologies.
Minor	**Specification**	**Treatment**
Social/cultural/religious	Following conventional top-down approaches.	Introduction of improved methods with more participation/ involvement of land users.

Participation and decision making

Target groups

Land users · SWC specialists/ extensionists · Planners · Politicians/ decision makers · Teachers/ students

Approach costs met by:

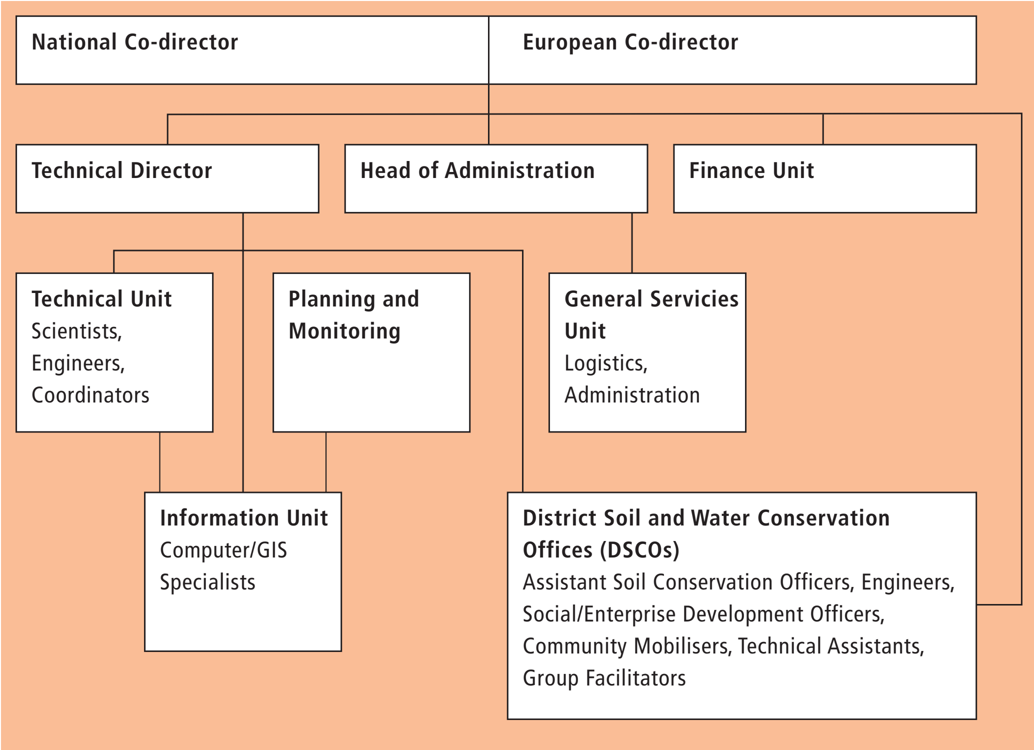
International agency: European Commission	81%
Community/local: Bagmati watershed	15%
National government: His Majesty's Government (Nepal)	4%
	100%

Decisions on choice of the technology: Mainly made by SWC specialist with consultation of land users; the land users were not aware of the technologies.
Decisions on method of implementing the technology: Mainly made by SWC specialist with consultation of land users; measures implemented required acquiring technical know-how for starting the work.
Approach designed by: Mainly international and national specialists, partly land users. In case of the landslip and stream bank stabilisation technology, the approach was mainly designed by programme staff of the Kathmandu District Soil Conservation Office.

Community involvement

Phase	Involvement	Activities
Initiation	interactive	rapid/participatory rural appraisal
Planning	interactive	rapid/participatory rural appraisal
Implementation	interactive	responsibility for major steps
Monitoring/evaluation	interactive	reporting, measurements/observations, public meetings, workshop/seminars
Research	interactive	on-farm trials

Differences in participation between men and women: The BIWMP in general had a bottom-up approach on planning and implementation and encouraged equitable involvement of women in activities. The decisions about implementing of the landslip and stream bank stabilisation technology were taken jointly by both men and women. However, contributions to the establishment and maintenance were made according to the traditional pattern of work allocation (for example digging mainly done by men, planting/watering mainly done by women).



Organogram
Organogram of the Bagmati Integrated Watershed Management Programme (BIWMP). The landslip and stream bank stabilisation work was implemented by the Kathmandu District Soil Conservation Office under the supervision of a ASCO (Assistant Soil Conservation Officer) Engineer.

Extension and promotion

Training: Training was provided on soil and water conservation in the form of visiting demonstration areas, farm visits and public meetings. The impact on land users and SWC specialists was excellent: after the training the land users and SWC specialists could easily implement horticultural, bioengineering, and agroforestry practices. The effectiveness of training on extension agents, planners and politicians was good, but only fair for teachers and students: there is still a lack of use of the outputs of the projects as educational materials.
Extension: The extension approach was Integrated Watershed Management with the following key elements: Participatory Rural Appraisal, trainings, farmer-to-farmer exchange, workshops, seminars and on-site demonstration. The impact of extension on land users was excellent. Extension focused on land users and SWC specialists together, and provided opportunities for them to test various technologies for watershed management. The involvement of village politicians, project decision makers and planners in monitoring the impact of extension, helped in the development of activities in watershed management for other areas.
Research: Research was a very important part of the approach. All research components (sociology, economics/marketing, ecology, technology) were covered (see key references) by various consultants and team staff members. Research activities were very efficient in contributing to the approach's effectiveness.
Importance of land use rights: Land use rights (including the security of traditional land use rights as in the case of the landslip and stream bank stabilisation technology) greatly helped the implementation of the approach.

Incentives

Labour: About 75% of the labour related to the landslip and stream bank stabilisation work was done voluntarily. The rest was paid in cash.
Inputs: Cement, bricks and stones for community infrastructure were fully financed by the programme, whereas seeds, seedlings, saplings were not (or only partly) financed.
Credit: No credit was provided.
Support to local institutions: The programme greatly supported local institutions by providing training and equipment.
Long-term impact of incentives: While there are clear positive environmental effects (because it ensures better management of a watershed and improved livelihood security for the families), there may be moderate negative impacts if the local communities are made dependant on external funds.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	ad hoc measurements of land use changes
Technical	regular observations of technology effects
Socio-cultural	regular observations of status
Economic/production	regular observations of cash income
Area treated	ad hoc measurements: GIS mapping
No. of land users involved	regular observations of numbers
Management of approach	regular monitoring reports

Impacts of the approach

Changes as result of monitoring and evaluation: The described approach was designed on the basis of results from monitoring and evaluation of the first phase of the BIWMP (1986–1992). With the initiation of the second phase in 1992 changes were mainly focused on building the capacity of community groups to plan, implement and continue development activities after the initial input was completed. Capacity was built by (1) providing community-level training; (2) supporting the installation of communication facilities (telephone, radio etc.); (3) developing a strategy for empowering women and disadvantaged groups; (4) assisting the establishment of community networks.
Improved soil and water management: The approach greatly helped to improve soil and water management through the promotion of many activities related to agroforestry, water harvesting, landslip stabilisation and community forestry which were adopted by the land users.
Adoption of the approach by other projects/land users: There is lack of evidence whether this approach was chosen to address landslip and stream bank erosion problems in other areas by other projects.
Sustainability: Uncertain: whether land users can and will continue activities without external support has to be monitored at a later stage.

Concluding statements

Strengths and ➜ how to sustain/improve	**Weaknesses** and ➜ how to overcome
Involves all key actors in the field of watershed management ➜ Institutionalise such approaches.	It is 'project focussed' ➜ Needs to be institutionalised.
Has helped the land users in adopting improved livelihood options ➜ Effective government and community programmes needs to be promoted.	It does not focus on landless families ➜ Design activities for the landless in watershed management.
It encourages land users communities and local institutions to participate in the planning and decision making process ➜ Involve them in the planning and decision making process.	Some of the activities with high input requirements may not be spontaneously adopted by poor land users ➜ Further research on how to reduce inputs or provide specific incentives for such disadvantaged groups.
The implementation of technologies through the approach is cost-effective and socio-culturally accepted ➜ Take into account the local resources and knowledge.	

Key reference(s): Mallik DB (2000) Working with Community. *Jaladhar – quarterly newsletter of Bagmati Integrated Watershed Management Programme.* Issue 2, July – December ▪ Bagmati Integrated Watershed Management Programme (1998, 1999, 2000, 2001) *Project Years 1–4, Annual Workplans July 1998–July 2002.* His Majesty's Government of Nepal, Ministry of Forest and Soil Conservation, Department of Soil Conservation and Watershed Management & Commission of European Communities. Kathmandu, Nepal
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