Left: Plastering a biodynamic compost heap with a paste made from a mixture of soil and cow dung. (Samden L Sherpa)
Right: A biodynamic compost heap prepared by alternately layering dry and green biomass. (Samden L Sherpa)

Biodynamic composting

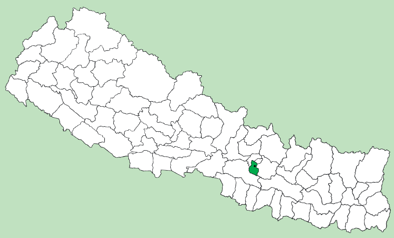
Nepal: जैवीक मल बनाउने तरिका

A faster and more effective way to produce high quality compost in large quantities by surface composting using dry and green farm biomass piled in a heap.

Biodynamic denotes a method of organic farming that emphasizes a holistic understanding of the interrelationships between soil, plants, and animals in a self-sustaining system. It excludes the use of artificial chemicals and stresses the importance of integrating farm animals, the cultivation of crops, and caring for the land. Fermented herbal and mineral preparations are used as compost additives and field sprays.

Biodynamic composting is an inexpensive means of producing a large amount of compost within a relatively short time compared to other methods. It is ideal for farmers who require large amounts of compost, such as for orchards; or when several households get together to produce and share compost. This type of composting also helps to store soil carbon, assists irrigation practices that keep fields alternatively moist and dry, works to decrease the number of soil pests, and reduces methane emission. This practice not only enhances agricultural production as an on-site benefit to the land users but also contributes to the off-site benefits enjoyed by downstream land users, since it helps to reduce sedimentation and increases water availability.

The biodynamic compost is prepared as a surface heap rather than in a traditional pit. The heap is built on a flat, dry site away from shade trees and other elements that would promote water logging. The farmer marks out a rectangular plot of land according to his needs and places a set of logs or PVC pipes lengthwise in the middle of the rectangle to facilitate air circulation and help aerate the pile. Alternating layers of dry and green biomass are added on top. Rock phosphate and crushed slaked lime are added to the middle layers to enhance decomposition and to supplement the mineral content. Once the layering is complete, the pile is sealed using a paste made from soil and cow dung. Over the ensuing two months, the pile is watered weekly (through holes made in the plaster layer which are then resealed) and is monitored; any cracks that appear in the external plaster are sealed. At the end of this time, the compost is tested to check if it is ready by taking samples from a few different locations in the heap. When a crushed sample smells like forest soil, it indicates that the degradation is 80% complete and that the compost is ready to use.



WOCAT database reference: QT NEP 35
Location: ICIMOD Knowledge Park at Godavari, Lalitpur District, Nepal.
Technology area: Demonstration plot
Conservation measure(s): Management
Land use type: Annual cropping
Stage of intervention: Prevention of land degradation
Origin: Experiment/demonstration/research
Climate: Sub-humid/temperate
Related approach: Not described
Other related technology: Improved compost preparation (QT NEP 7), Better quality farmyard manure through improved decomposition(QT NEP 8), Improved farmyard manure through sunlight, rain and runoff protection (QT NEP 9), Black plastic covered farmyard manure (QT NEP 16)
Compiled by: Samden L. Sherpa, ICMOD
Date: May 2011, updated March 2013

The technology was documented using the WOCAT (www.wocat.org) tool.

ICIMOD WOCAT

Classification

Land use problems

Crop productivity is limited by poor soil fertility, intense cropping, and a scarcity of irrigation water. Farmers in the hills notice a marked decrease in the health of their crops and degraded soil conditions when chemical fertilizers are overused. Biodynamic composting is a low input response to this problem.

Land use

Annual crop (rainfed)

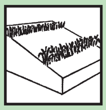
Climate

Sub-humid/ temperate

Degradation

Chemical deterioration: decreased fertility

Conservation measures



Management: Improved compost quality

Stage of intervention

- **Prevention**
- Mitigation/reduction
- Rehabilitation

Origin

- Land users' initiative:
- **Research: demonstration**
- Externally introduced:
- Other (specify)

Level of technical knowledge

- Low
- **Medium: land users and technicians**
- High

Technical function/impact

Main:
- Increases soil fertility and productivity
- Increases the organic matter content of the soil
- Improves the physical condition of the soil

Secondary:
- Improves the physical properties of the soil
- Increases infiltration rate
- Improves water retention capacity of the soil

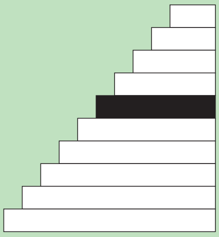
Environment

Natural environment

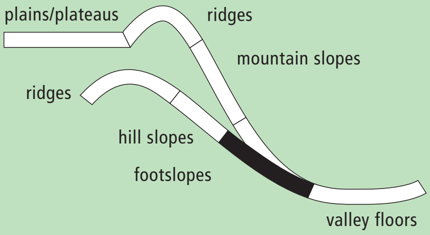
Average annual rainfall (mm)

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

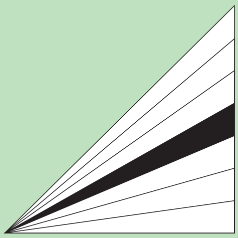
Altitude (masl)



Landform



Slope (%)



Soil depth (cm)

- **0–20**
- 20–50
- 50–80
- 80–120
- >20

Growing season(s): not relevant
Soil texture: medium loam
Soil fertility: medium
Topsoil organic matter: high (>3%)
Soil drainage/infiltration: poor
Soil erodibility: medium

Soil water storage capacity: medium
Ground water table: <5 m
Availability of surface water: good
Water quality: good for drinking and agricultural use
Biodiversity: high (695 species of flora and 230 species of fauna have been documented within the Park's 30 ha area)

Human environment

Crop land per household (ha)

- <0.5
- **0.5–1**
- 1–2
- 2–5
- 5–15
- 15–50
- 50–100
- 100–500
- 500–1000
- 1000–10000
- >10000

Land user: for demonstration and experiment
Population density: >10 persons per km^2
Land ownership: government
Land/water use rights: community/individual
Relative level of wealth: neighbouring communities are poor
Importance of off-farm income: >50% of all households around the demonstration site have off-farm income
Access to services and infrastructure: labour available; road access used to transport crops

Market orientation: mixed subsistence and commercial in the vicinity of the demonstration site
Mechanization: manual and animal traction
Number of livestock: in the vicinity of the demonstration site poor households may have a few goats whereas wealthier farmers often own several cattle
Purpose of forest/woodland use: fodder, fuelwood
Types of other land: scrubland
Level of technical knowledge required: simple to low

A biodynamic composting heap	Top	
6th layer Green biomass+water+cow dung slurry The heap is sealed with a paste made of cow dung and soil.	Thickness (approx.) 22 cm	**Comment:** Add green biomass then seal the heap by plastering over the top and sides using a paste made from soil and cow dung (3:1 ratio) to make it air tight. The final heap should be approximately 1.2 m high.
5th layer Dry biomass+water+cow dung slurry	15 cm	Add dry biomass, moisten with water and cow dung slurry.
4th layer Green biomass+water+slacked lime	15 cm	Add green biomass; moistened with water and cover with a layer of crushed slaked lime (approx. 30 kg).
3rd layer Dry biomass+water+rock phosphate	15 cm	Add dry biomass, moisten with water and then sprinkle with crushed bone meal or crushed rock phosphate (approx. 30 kg).
2nd layer Green biomass+water+cow dung slurry	15 cm	Add green biomass; moisten with water and cow dung slurry.
1st layer Dry biomass+water+cow dung slurry Logs or PVC pipes for aeration	22 cm	Demarcate a rectangular plot area which measures approx. 5 m X 2 m and place logs or PVC pipes at the middle of the rectangle. Make a first layer of thoroughly drenched dry biomass and apply cow dung slurry in the form thick paste to cover this layer completely.
Bottom – ground level		

Technical drawing
Layering of the different materials in a biodynamic compost heap

Implementation activities, inputs and costs

Establishment activities

The composting takes place above ground and the heap is energized by additives which not only enhance the nutrient content of the compost but also make the decomposition process faster. The additives required include cow dung, crushed lime, rock phosphate (or bone meal), and dry and green farm matter. The compost heap is assembled in less than one day and the compost is ready to use within two months (under weather and temperature conditions similar to those at the ICIMOD Knowledge Park).

Note: If rock phosphate is not available, crushed stone dust can be substituted.

Establishment inputs and costs per unit (average)

Inputs	Cost (USD)	% met by land user
Materials		
- Cow dung (300 kg)	30	
- Lime and rock phosphate (25 kg each)	20	
Labour (Biomass/soil collection, heap preparation)	80	
Equipment		
Shovel, chopping machine, bucket, bamboo, rope	20	
TOTAL	**150**	**0%**

Maintenance/recurrent activities

The compost heap is punctured weekly in order to add water; after watering, the punctures are resealed using cow dung.

Maintenance/recurrent inputs and costs per unit per year

Inputs	Cost (USD)	% met by land user
Labour	25	
Manure	10	
TOTAL	**35**	**0%**

Remarks:

- All costs and amounts are rough estimates by the technicians and authors. Exchange rate USD 1 = NPR 71 in May 2011.
- This was a demonstration project conducted by ICIMOD.

Impacts of the technology

Production and socioeconomic benefits	Production and socioeconomic disadvantages
+++ Increased crop yields +++ Increased farm income +++ Reduced expenses for purchasing chemical fertilizers	none
Socio-cultural benefits	**Socio-cultural disadvantages**
+++ Improved knowledge on biodynamic composting +++ Improved knowledge on soil conservation and soil fertility	none
Ecological benefits	**Ecological disadvantages**
+++ Increased organic matter and nutrients in the soil; it is used for intercropping +++ Better compost encourages farmers to diversify crops to include mixed farming and biodiversity is enhanced +++ Decreased use of chemical fertilizers	none
Off-site benefit	**Off-site disadvantages**
+++ Environmentally friendly: keeps village cleaner by recycling waste matter and produces large amounts of compost	none

Comments: Biodynamic composting is an advanced farming system that is gaining popularity because it improves the quality of crops and the health of the soil. The use of biodynamic compost improves soil fertility; increases agricultural production, and contributes to improved livelihoods.

Benefits/costs according to the land user

The land user enjoys both short and long-term benefits; in the short term there is a reduced need for costly chemical/mineral fertilizers and in the long term the health of the soil improves. Locally available dry and green biomass can be used for making biodynamic compost. The only extra costs arise from the need for lime, rock phosphate, and labour.

Benefits compared with costs	short-term	long-term
Establishment	positive	positive
Maintenance/recurrent	positive	positive

Acceptance/adoption:
The biodynamic composting technique found a high rate of acceptance with orchard and vegetable farmers. ICIMOD provided farmers from the Godavari and Bishankhunarayan Village Development Committee areas with training on biodynamic composting. The farmers who need a large amount of compost, such as those who have orchards, have adopted the technique and are now producing the compost themselves.

Drivers for adoption:
- The technology is simple and inexpensive; it can be implemented using local materials.
- The biodynamic method is faster and produces more compost than traditional methods.
- The conditions promote complete decomposition and help to reduce the incidence of soil pests.

Constraints
- There is some initial investment cost in terms of the labour needed to collect biomass/soil and to construct the heap.
- This composting method is limited to farmers who keep livestock because fresh cow dung is needed.

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
The main advantage of this method is that the composting process is completed within 60 days, whereas the traditional method requires more than 120 days. The biodynamic compost itself is very fine and decomposition takes place uniformly from top to bottom in the heap. → Share experiences with a wider audience and provide training to replicate the technology.	Large amounts of biomass are not always available. → Rice and wheat straw can also be used if forest biomass is not easily available.
The quality of biodynamic compost is better than that of traditionally prepared compost. The nutrient content of N, P, K, and organic matter, and the C/N ratio, are higher. → as above	Rock phosphate is not always available → crushed stone dust can be substituted.
This method is suitable for producing large amounts of compost. → as above	
Promotes organic production of desired crops and avoids the need for chemical fertilizers → as above	

Key reference(s): Diver, S (1999) *Biodynamic farming and compost preparation.* Pethuparai, India: BDAI Secretariat, Ichor Estate
Contact person(s): Mr Samden Lama Sherpa, ICIMOD, P.O. Box 3226, Kathmandu, Nepal; Tel: +977 1 5003222; Email: ssherpa@icimod.org
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Left: Farmer collecting slashed materials for the construction of contour bunds (BB Tamang)
Right: Contour bunds constructed with dry slashed materials (BB Tamang)

Contour bunding

Nepal: भाँजो राख्ने

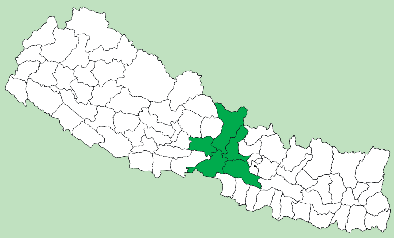
A traditional low-cost method of soil conservation suitable for sloping land; it promotes water retention and helps prevent erosion.

Contour bunding is a proven sustainable land management practice for marginal, sloping, and hilly land where the soil productivity is very low. It is widely adopted by the ethnic minorities of Nepal who practice the shifting cultivation system of farming. Over generations, they have successfully used this technology to control soil erosion, promote water retention, and increase crop production. It has a high probability of replication because it is simple to implement, is low cost, and makes the maximum use of local resources.

Farmers use a multi-step process to promote the formation of rough terraces along contour lines on sloping land. First the vegetation on the shifting cultivation plot (mostly fodder and forage trees and bushes) is cut down and the leaves and small twigs removed from the branches by slashing. All the material is left on the surface to dry. The leaves and twigs gradually decompose. After a few weeks, the remaining dry material is rolled into bundles and arranged along contour lines. The material is anchored with pegs, stones, and (where possible) tree stumps. This is the beginning of the contour bund. The farmers then incorporate the remaining leaf litter and decomposed organic matter into the soil between the bunds and plant crops. Over time, as the soil gradually deposits above each bund and is eroded below, rough terraces are formed. The process is labour intensive and farmers need to regularly check and maintain the bunds to allow the soil to collect.

Contour bunding is relatively easy to establish and maintain since it does not require external inputs and local unskilled labourers can make them using locally available woody materials. It is also both sustainable and ecofriendly since there are no external inputs and no organic matter is burned in the process.

The use of contour bunding is limited by the fact that it is labour intensive and that bunding cannot be implemented during the fallow period of the shifting cultivation cycle, thus it can only be applied on a plot for two years (the cultivation period of the shifting cultivation cycle).



WOCAT database reference: QT NEP 26
Location: Chitwan, Tanahun, Gorkha, Dhading and Makawanpur Districts, Nepal
Technology area: 1–10 km^2
Conservation measure(s): Structural
Land use: Mixed land: agroforestry
Stage of intervention: Mitigation/ reduction of land degradation
Origin: Initiated by the land users
Climate: Subhumid/subtropical
Other related technology: Improved terraces (QT NEP 2)
Compiled by: Bir Bahadur Tamang, LI-BIRD
Date: March 2010, updated March 2013

The technology was documented using the WOCAT (www.wocat.org) tool.

Classification

Land use problems

Shifting cultivation is a traditional farming system practice used by the ethnic minorities who farm marginal, hilly, and sloping land. Erratic rainfall and improper land use practices all contribute to land Rock phosphate is not always available ➔ crushed stone dust can be substituted. degradation.

Land use

Agroforestry: crops and trees on rainfed land

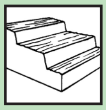
Climate

Subhumid/ subtropical

Degradation

Water erosion: topsoil is lost during rainfall

Conservation measures



Structural measure: barriers

Stage of intervention

- □ Prevention
- ■ Mitigation/reduction
- □ Rehabilitation

Origin

- ■ Land users' initiative
- □ Experiments/research
- □ Externally introduced
- □ Other (specify)

Level of technical knowledge

- □ Low
- ■ Medium: land users
- □ High

Main causes of land degradation: over exploitation of the land, degradation by natural erosion, population pressures are forcing the farmers to overexploit these marginal lands

Technical function/impact

Main: Traps dispersed runoff

Secondary:
- Increases organic matter in the soil
- Increases water retention

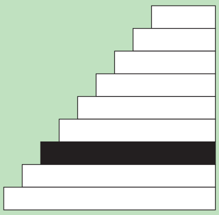
Environment

Natural environment

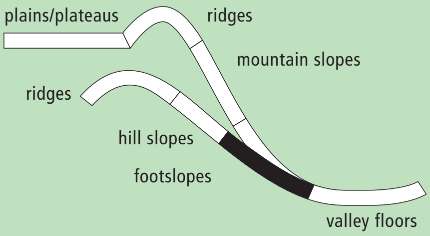
Average annual rainfall (mm)

- □ >4000
- □ 3000–4000
- □ 2000–3000
- □ 1500–2000
- □ 1000–1500
- ■ 750–1000
- □ 500–750
- □ 250–500
- □ <250

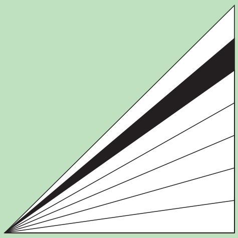
Altitude (masl)



Landform



Landform Slope (%)



Soil depth (cm)

- ■ 0–20
- □ 20–50
- □ 50–80
- □ 80–120
- □ >20

Growing season(s): two
Soil texture: coarse/light, sandy soil
Soil fertility: low
Topsoil organic matter: medium (1–3%)
Tolerant of climatic extremes: such as droughts

Sensitive to climatic extremes: yes
Soil water storage capacity: very low
Ground water table: <50 m
Availability of surface water: poor to none
Water quality: NA

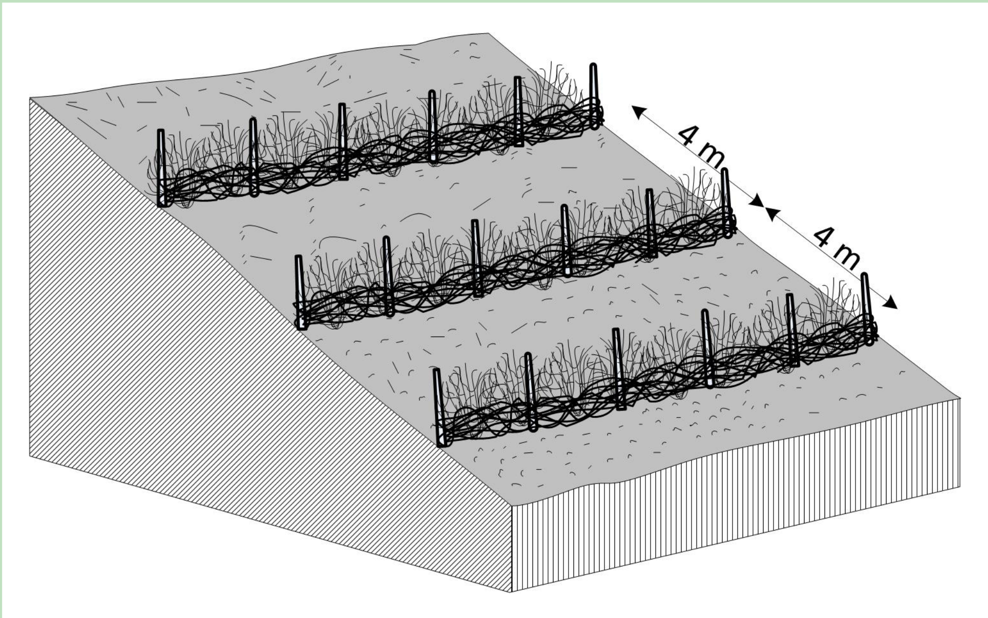
Human environment

Crop land per household (ha)

- □ <0.5
- ■ 0.5–1
- □ 1–2
- □ 2–5
- □ 5–15
- □ 15–50
- □ 50–100
- □ 100–500
- □ 500–1000
- □ 1000–10000
- □ >10000

Land user: individual or household
Population density: 10–50 persons per km²
Annual population growth: 2–3%
Land ownership: individual, not titled
Land/water use rights: customary rights: water-open access
Relative level of wealth: poor
Importance of off-farm income: 10–50% of all income is off-farm

Access to services and infrastructure: moderate
Market orientation: subsistence
Mechanization: manual labour
Livestock grazing on cropland: yes
Livestock density: not applicable
Purpose of forest/woodland use: not applicable
Types of other land: not applicable



Technical drawing
Contour bunding on sloping land; after leafy matter is slashed and allowed to dry it is gathered into bunds and anchored into place using locally available materials such as twigs and stones; note that the bunds are typically spaced about 4 m apart.
(BB Tamang and AK Thaku)

Implementation activities, inputs and costs

Establishment activities

- The vegetation on the plots (leafy fodder and others) is slashed and allowed to dry on the sloping land.
- The dried, slashed materials are chopped and allowed to partially decompose naturally on the soil.
- The dry materials are collected along contour lines and anchored into place using locally available materials.
- The land between the bund lines is enriched with the leaf litter and crops are planted.

Establishment inputs and costs per ha (average)

Inputs	Cost (USD)	% met by land user
Labour (16 person days)	43	100%
TOTAL	**43**	**100%**

Maintenance/recurrent activities

The bunding is periodically checked and lapsed areas are repaired as needed.

Maintenance/recurrent inputs and costs per ha per year

Inputs	Cost (USD)	% met by land user
Labour (4 person days)	11	100%
TOTAL	**11**	**100%**

Remarks:
- The cost of implementing this technology is dependent on the gradient of the slope (and other geographical features) and the availability of labour.
- All costs and amounts are rough estimates by the technicians and authors. Exchange rate USD 1 = NPR 73 in March 2010

Impacts of the technology*

Production and socioeconomic benefits	
+ + +	Simplified farm operations
+ +	Increased crop yield
+ +	Diversified income sources
+ +	Increased farm income
+	Reduced expenses on agricultural inputs
	Increased product diversification

Production and socioeconomic disadvantages	
− −	Reduced wood production
−	Increased labour constraints

Socio-cultural benefits	
+ +	Improved knowledge of conservation/erosion
+ +	Improved food security/self-sufficiency (reduced dependence on external inputs)
+	Improved health
+	Strengthened community institutions

Socio-cultural disadvantages	
−	Introducing this practice into areas where it is not a customary practice may upset traditional norms

Ecological benefits	
+ +	Increased organic matter in the soil
+ +	Increased nutrient cycling/recharge
+	Improved soil cover
+	Increased soil moisture
+	Reduced soil loss

Ecological disadvantages	
−	Increased competition (water, sunlight, nutrients)
−	Increased habitat fragmentation
−	Increased niches for pests (birds, slugs, rodents, etc.)

Off-site benefit	
+ +	Reduced downstream flooding
+ +	Reduced downstream siltation
+	Reduced amount of sediments transported by wind
+	Improved buffering/filtering capacity (by soil, vegetation, wetlands)

Off-site disadvantages

none

Contribution to human wellbeing/livelihood	
+	Increase crop production, with associated increase in income and improved human health

Benefits/costs according to the land user

Average cost required to establish and maintain this technology is low and the long-term benefits are high.

Benefits compared with costs	short-term	long-term
Establishment	slightly positive	positive
Maintenance/recurrent	positive	very positive

Acceptance/adoption:

About 200 land user families have voluntarily adopted this technology in Tanahun, Chitawan, Gorkha, Dhading, and Makawanpur Districts of Nepal.

Concluding statements

Strengths and ➔ how to sustain/improve	**Weaknesses** and ➔ how to overcome
Decreased soil erosion and increased productivity of the soil ➔ Formation of permanent bunds and terraces; adds organic matter to the soil	Slashing contributes to the risk of forest fires ➔ After drying, the slashed materials should be rolled out within a week
Natural terrace formation and decreasing slope gradient ➔ Over time, as more soil deposits on the bunds, the gradient is naturally decreased	When too many trees are slashed it can promote landslides ➔ Grow trees along the bunds; fodder trees are especially beneficial
As the organic matter content increases, humus soil is formed and the soil fertility increases ➔ Continue to accumulate crop residues on the surface; these will decompose and increase the organic matter content of the soil	Bunds may harbour biological pests such as rodents ➔ Regular maintenance and pest control can help to limit unwanted wildlife

Key reference(s): Regmi, BR; Aryal, KP; Subedi, A; Shrestha, PK; Tamang, BB (2001) *Indigenous knowledge of farmers in the shifting cultivation areas of Western Nepal.* Pokhara, Nepal: LI-BIRD

Contact person(s): Bir Bahadur Tamang; LI-BIRD, Gairapatan, Pokhara, Nepal, P.O. Box 324; Tel: +977 61 526834 (O); 9746005992 (M); Email: info@libird.org, btamang@libird.org

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Left: The gully with bio-engineered check dam in the foreground and shrine in the background. (Duncan Scott)
Right: A retaining wall built using earth-filled sacks and bamboo posts. Tree seedlings and local grasses are planted on top of the retaining wall to help stabilize it. (Sabita Aryal Khanna)

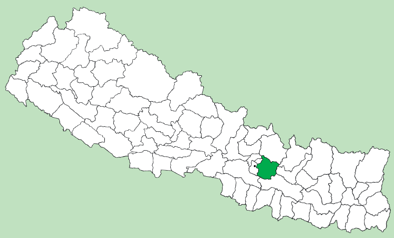
Sustainable land management using controlled gullying in 'jagidol' areas

Nepal: “जागिडोल” क्षेत्रमा खोल्सि सुधारद्वारा दीगो भू-व्यवस्थापन

An indigenous technology to help control channelled water during the rainy season and conserve it during the dry season

For more than two centuries, local farmers have promoted soil and water conservation by protecting the gullies which occur naturally between rice terraces; thus the land area is called ‘jagidol’ (jagi=rice, dol=gully). The small perennial streams which flow through the terraces are protected by constructing check dams and retaining walls to reduce the danger of erosion and collapse.

During the monsoon, the channels or trenches can become engorged and, since their walls are not reinforced (except for grass planted at the edges), the conduits can be easily eroded. When the erosion is severe enough, the edges of the terraces adjacent to the gullies can collapse. When many gullies collapse at once, the stability of the entire hillside is threatened with catastrophic consequences for the village situated above the planting area. Villagers have traditionally used local materials and expertise to maintain the gullies and reduce soil erosion by building retaining walls across the slope which are strengthened through plantation. The retaining walls are bio-engineered using a combination of bamboo poles, rocks, and soil-filled sacks. Bamboo poles are used for the backbone of the support structure, and rocks and soil-filled sacks are used to line the sides of the channel. Local grasses such as 'sitto' are planted on the top and, as they grow, their roots help to anchor the structure. When the channels are fortified by retaining walls and planting, they become entrenched and, over time, less maintenance is required. As a bonus, when the plants grown along the gullies mature, they provide biomass for the farm and fodder for cattle. During winter, when water is scarce, farmers modify the gully system by constructing check dams which can be used to collect water in one place. These dams are useful for irrigation during the dry season and they also help to prevent bed scouring.



WOCAT database reference: QT NEP 25
Location: Sharada Batase VDC, Kabhrepalanchok District, Nepal
Technology area: 1.1 km^2
Conservation measure(s): Vegetative, structural, and management measures
Land Use: Waterways, drainage channels, ponds, dams
Stage of intervention: Mitigation/ reduction of land degradation
Origin: Has been practised for generations by the local communities
Climate: Subhumid/sub-tropical
Related approach: Gullies – a traditional sustainable land management practice (QA NEP 25)
Other related technology: Gully plugging using check dams (QT NEP 14)
Compiled by: Sabita Aryal Khanna, Kathmandu University
Date: December 2010, updated March 2013

The technology was documented using the WOCAT (www.wocat.org) tool.

ICIMOD

WOCAT

Classification

Land use problems

As the land is continuously eroded, both farmland and inhabited areas will slowly slide downhill.

Land use

Drainage of waterways

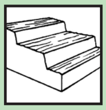
Climate

Subhumid/ tropical

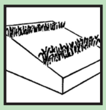
Degradation

Gullies are eroded by water/ landslides can occur

Conservation measures



structural measure



vegetative measure

Stage of intervention

- ■ Prevention
- □ Mitigation/reduction
- □ Rehabilitation

Origin

- ■ Land users' initiative: >50 years
- □ Experiments/research
- □ Externally introduced
- □ Other (specify)

Level of technical knowledge

- □ Low
- ■ Medium: land user
- □ High

Main causes of land degradation: deforestation/removal of natural vegetation, over-exploitation of farmland, poor crop management

Technical function/impact

Main:
- Controls concentrated runoff (drain/divert)
- Stabilizes soil by controlling runoff during monsoon
- Collects water during the dry season

Secondary:
- Improves ground cover
- Improves management and diversification of land use

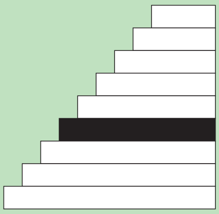
Environment

Natural environment

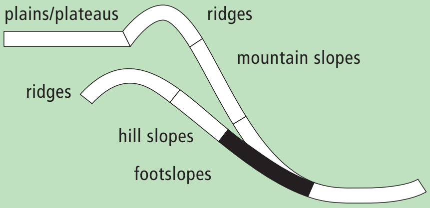
Average annual rainfall (mm)

- □ >4000
- □ 3000–4000
- □ 2000–3000
- □ 1500–2000
- ■ 1000–1500
- □ 750–1000
- □ 500–750
- □ 250–500
- □ <250

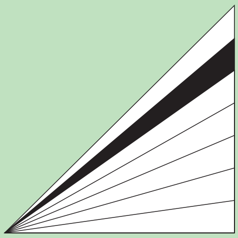
Altitude (masl)



Landform



Slope (%)



Soil depth (cm)

- □ 0–20
- □ 20–50
- ■ 50–80
- □ 80–120
- □ >20

Growing season(s): two
Soil texture: fine/heavy (clay)
Soil fertility: high
Topsoil organic matter: high (>3%)
Soil drainage/infiltration: Poor
Soil water storage capacity: medium

Ground water table: 5–50 m
Availability of surface water: excess during monsoon
Water quality: good for agricultural use but not for drinking water
Biodiversity: high

Tolerant of climatic extremes: increases/decreases in temperature and seasonal rainfall
Sensitive to climatic extremes: heavy rainfall events (intensity and amount), and increases in seasonal rainfall
If sensitive, what modifications were made/are possible: can be improved by reinforcing the gullies (e.g., use concrete); when gullies are reinforced it is possible to plant a more diverse variety of crops

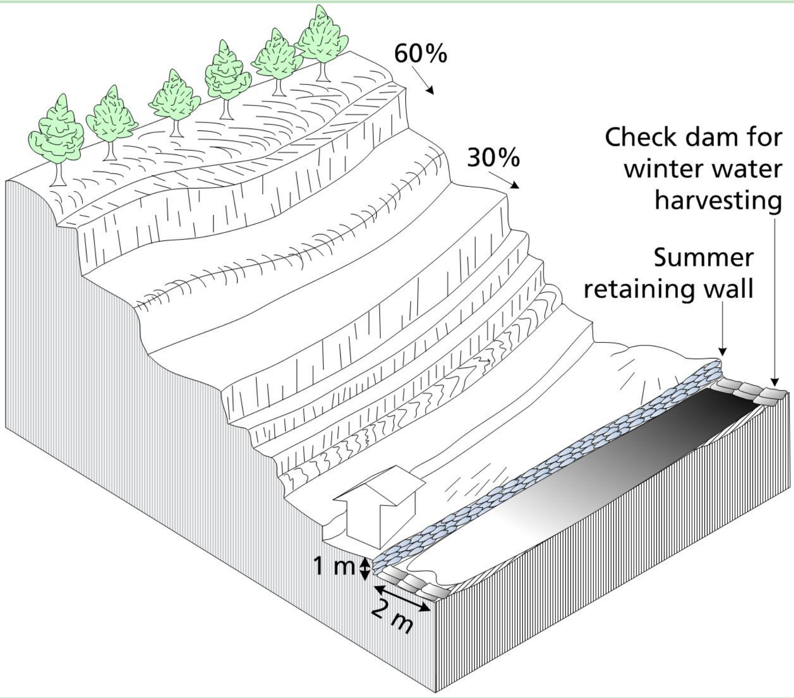
Human environment

Crop land per household (ha)

- ■ <0.5
- □ 0.5–1
- □ 1–2
- □ 2–5
- □ 5–15
- □ 15–50
- □ 50–100
- □ 100–500
- □ 500–1000
- □ 1000–10000
- □ >10000

Land user: individual households, groups/community (small scale)
Population density: 10–50 persons per km^2
Annual population growth: 0.5–1%
Land ownership: individual, titled, and communal/village
Land/water use rights: land, individual;, water, open access
Relative level of wealth: about 90% have the same level of wealth
Importance of off-farm income: > 50% of households have some off-farm income

Access to services and infrastructure: moderate
Market orientation: subsistence
Mechanization: not mechanized
Livestock grazing on cropland: Some
Livestock density: <1 LU/ km^2
Purpose of forest/woodland use: fuelwood, timber, fodder
Types of other land: wasteland



Technical drawing
A jagidol area showing the approximate slope, bench terraces, and basic geometry of the landscape. With the shrine shown as in the photograph of the site. (Duncan Scott, A. K. Thaku)

Implementation activities, inputs and costs

Establishment activities

Vegetative
Local grasses such as *utis, sito, amrisho, daleghas,* and bamboo, can be planted on top of the reinforcements.

Structural
- Construction of dam with mud-filled sacks
- Construction of stone dam and spillways
- Construction of retaining wall
- Construction of bunds and barrier

Establishment inputs and costs per 1.1 km²

Inputs	Cost (USD)	% met by land user
Labour (150 person days)	670	100%
Equipment	225	100%
Materials	725	100%
TOTAL	**1620**	**100%**

Maintenance/recurrent activities
- Continue to reinforce by planting with local grasses or bamboo on top of the structures until the plantings are well established.

Maintenance/recurrent inputs and costs per 1.1 km² per year

Inputs	Cost (USD)	% met by land user
Labour (50 person days)	250	100%
Equipment	70	100%
Materials	350	100%
TOTAL	**670**	**100%**

Remarks:
- All costs and amounts are rough estimates by the technicians and authors. Exchange rate USD 1 = NPR 72 in December 2010.
- The construction and maintenance of gullies demands attention during a busy agricultural calendar and can significantly add to the labour costs depending on the size and number of gullies and dams that need to be constructed and maintained.

Impacts of the technology

Production and socioeconomic benefits		Production and socioeconomic disadvantages	
+ + +	Reduced risk of land degradation	− − −	Labour-intensive preparation and maintenance
+ + +	Increased fodder production		
+ +	Increased crop yield		
+ +	Reduced risk of crop failure		
+ +	Increased availability of water for irrigation		
+ +	Increased production of fodder and biomass		

Socio-cultural benefits		Socio-cultural disadvantages	
+ + +	Improved agriculture benefits the whole community at many different levels including social and cultural	−	Conflicts between land owner and other shrine visitors
+ + +	improved cultural opportunities (eg spiritual, aesthetic, others) for Improvement of conservation/erosion knowledge		

Ecological benefits		Ecological disadvantages	
+ + +	Improved resilience in the event of extreme events such as droughts, floods, and storms	−	Increased competition for water, sunlight, and nutrients
+ + +	Reduced soil loss	−	Agricultural pests such as birds, slugs, and rodents, are more easily harboured in and near the edges of gullies
+ +	Increased water availability		
+ +	Habitat diversity is maintained and increased		
+ +	Surface runoff water is more easily collected		

Off-site benefit		Off-site disadvantages	
+ + +	Reduced downstream flooding		none
+ + +	Downstream neighbouring fields also benefit from slope stability and soil conservation		

Contribution to human wellbeing/livelihood

+ + Improved agriculture leads to food sufficiency, enhanced economic conditions, and better health throughout the community. When households have more cash income they usually invest it in education for their children.

Benefits/costs according to the land user

When both vegetative and structural measures are implemented together the long-term stability is improved.

Benefits compared with costs	short-term	long-term
Establishment	positive	very positive
Maintenance/recurrent	very positive	very positive

Acceptance/adoption:

Communities throughout the area have adopted these structural measures for centuries without any external support. Communities downstream are beginning to see the benefits and they are also starting to adopt these measures.

Concluding statements

Strengths and ➔how to sustain/improve	**Weaknesses** and ➔how to overcome
This is a well-accepted local practice. ➔ Continue to implement this soil conservation measure.	The traditional materials used in the construction of dams and gullies are prone to damage during flood events. ➔ The technology can be enhanced by the use of better materials and technical support. With research and funding, more robust conservation measures can be implemented.
The use of mud-filled sacs is a recent innovation. ➔ Some advance training may be needed.	In recent times, new activities such as brick making are coming to the villages; the entrepreneurs involved in these activities do not know about (and are not interested in) soil conservation measures. ➔ Increase awareness among newcomers.
Reduced risk of losing crops and agricultural land because of soil degradation. ➔ Continue to add to mud-based structures by vegetative means.	There has never been any external support for these soil conservation activities even if downstream communities also benefit. ➔ Increase awareness among downstream communities. Explore possibilities for external support for controlled gullying.
An added benefit is the production of biomass: grass, fodder for animals, wood, and fuelwood. ➔ Continue to plant more trees.	
Makes water available for irrigation even during the dry season. ➔Encourage more check dam construction along the gully.	

Key reference(s): None
Contact person(s): Sabita Aryal Khanna, Kathmandu University; Email: sabita@ku.edu.np, sabitaaryal@hotmail.com Tel: 9841540579 (M)
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Left: Hedgerow terraces are slowly formed when fodder and forage plants are cultivated along the bunds. (Gyanbandhu Sharma)
Right: Initial stage of establishing hedgerow technology on sloping land (Gyanbandhu Sharma)

Hedgerow technology

Nepal: घाँसेहार प्रबिधि

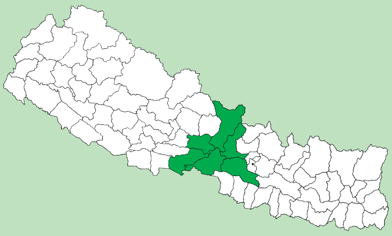
A technology that uses hedgerows to help establish terraces on sloping land; farmers learn improved methods to manage a cultivation practice that stabilizes the soil, enhances food production, and adds to on-farm cash income.

Hedgerow technology provides options and opportunities for farmers working on sloping land. These hedgerows are a soil conservation measure but they also help to generate additional biomass and fodder and/or income for marginal farmers; in addition, they offer the added benefit of helping to balance the ecosystem and to address climate change by encouraging biodiversity. This improved version of a local technology makes maximum use of indigenous knowledge and adds to it by making available the latest scientific knowledge.

Farmers have traditionally selected plants for hedgerow cultivation based on practical considerations such as the availability of seeds and seedlings, how well seeds germinate, how well the plants grow and how well they can be coppiced, their branching habit, the amount of biomass they can produce, and how much cash the crop can generate. They made these choices without the benefit of any external input or scientific knowledge, relying solely on what they have been able to observe locally over the years. The participatory technology development process aims to help farmers by providing them with scientific input to augment their traditional knowledge on the selection, plan, and design of hedgerows. Over a very short time, the farmers learn to make good use of the new information and start enjoying the benefits that the improved agriculture yields in terms of social, economic, and environmental benefits.

The following steps outline how hedgerows can be established on sloping land:

- A participatory designing and planning process is used to choose which sloping lands will be cultivated and to select which hedgerow species are to be planted. Trained manpower is recruited with the help of farmers and other related stakeholders.
- The necessary materials such as A-frames, seeds, and seedlings are prepared.
- The technology is implemented in the field by trained manpower.
- The hedgerow seedlings are regularly maintained.
- The land users participate in periodic monitoring and evaluation of the technology. They report on progress and provide feedback.



WOCAT database reference: QT NEP 27
Location: Gorkha, Tanhun, Chitwan, Makwanpur, Nawalparasi, Dhading Districts, Nepal
Technology area: 1–10 km^2
Conservation measure(s): Vegetative and land management
Land Use: Mixed cropping and agroforestry
Stage of intervention: Preventing land degradation
Origin: Experimental/research
Climate: Subhumid/subtropical
Related approach: Participatory hedgerow management (QA NEP 27)
Other related technology: Gully plugging using check dams (QT NEP 14)
Compiled by: Gyanbandhu Sharma (LI-BIRD)
Date: : October 2009, updated March 2013

The technology was documented using the WOCAT (www.wocat.org) tool.

ICIMOD LI-BIRD WOCAT

Classification

Land use problems

Noticeable soil erosion, decreased soil fertility, diminished productivity, and lower moisture content in areas that have sloping lands and in areas where shifting cultivation is or was practised. Plots that had previously been farmed by the method of shifting cultivation, where plots are allowed to lie fallow for a number of years, are now cultivated annually. This land use change is worrying because shifting cultivation has traditionally been practised in areas where the quality of the soil is poor and cannot support annual crop production year on year.

Land use

Mixed cropping and agroforestry (rainfed)

Climate

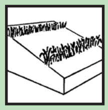
Subhumid/ subtropical

Degradation

Water erosion; loss of topsoil by water, gully erosion, and landslides

Nutrient depletion and reduced fertility by overuse of chemical fertilizers; reduced organic matter content in soil

Conservation measures



Vegetative measure

Management measure

Stage of intervention

- ■ Prevention
- □ Mitigation/reduction
- □ Rehabilitation

Origin

- □ Land users' initiative
- ■ Experiment/research: LI-BIRD
- □ Externally introduced
- □ Other (specify)

Level of technical knowledge

- □ Low
- ■ Medium: land user, field staff
- □ High

Main causes of land degradation: heavy/extreme rainfall, droughts, poor soil management, deforestation

Technical function/impact

Main:
- Prevents soil erosion
- Controls dispersed runoff; hedgerows help to trap and retain water

Secondary:
- Where the soil is stabilized by vegetation landslides occur less frequently
- Increases nutrient content in the soil (supply, recycling)
- Reduces slope gradient

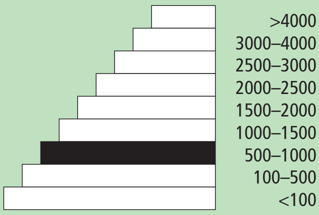
Environment

Natural environment

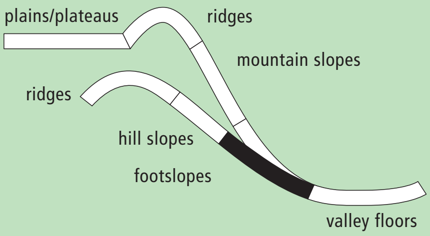
Average annual rainfall (mm)

- □ >4000
- □ 3000–4000
- □ 2000–3000
- □ 1500–2000
- ■ 1000–1500
- □ 750–1000
- □ 500–750
- □ 250–500
- □ <250

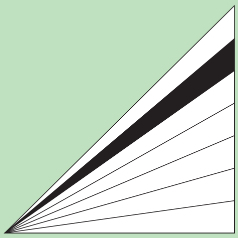
Altitude (masl)



Landform



Slope (%)



Soil depth (cm)

- ■ 0–20
- □ 20–50
- □ 50–80
- □ 80–120
- □ >20

Growing season(s): two
Soil texture: coarse/light (sandy)
Soil fertility: low
Topsoil organic matter: medium (1–3%)
Soil drainage/infiltration: poor

Soil water storage capacity: low
Ground water table: >50 m
Availability of surface water: poor/none
Water quality: poor
Biodiversity: low

Tolerant of climatic extremes: droughts, decrease in seasonal rainfall
Sensitive to climatic extremes: heavy rainfall events
If sensitive, what modifications were made/are possible: farmers select species with deep roots to adapt to climate extremes

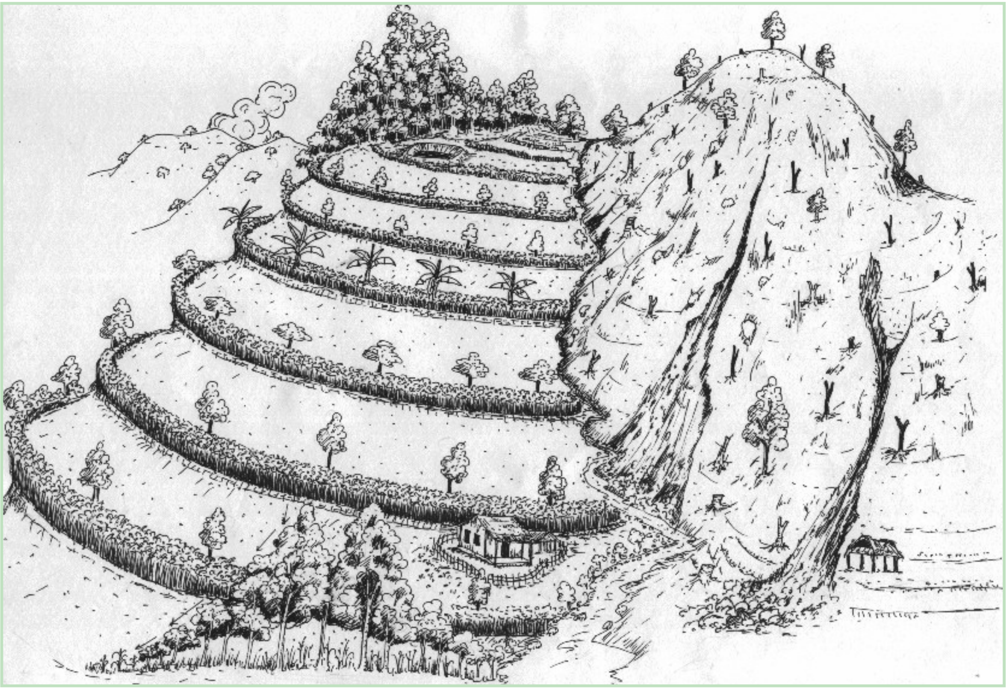
Human environment

Crop land per household (ha)

- □ <0.5
- ■ 0.5–1
- □ 1–2
- □ 2–5
- □ 5–15
- □ 15–50
- □ 50–100
- □ 100–500
- □ 500–1000
- □ 1000–10000
- □ >10000

Land user: individual or household
Population density: 10–50 persons per km^2
Annual population growth: 3–4%
Land ownership: individual, titled
Land/water use rights: : poor
Relative level of wealth: poor
Importance of off-farm income: 10–50% of all income

Access to services and infrastructure: moderate
Market orientation: subsistence
Mechanization: manual labour, animal traction
Livestock grazing on cropland: limited
Livestock density: low
Purpose of forest/woodland use: not applicable



Technical drawing
Hedgerow technology on sloping land; note that the hedgerows help to stabilize the land and to control soil erosion and runoff. (Bir Bahadur Tamang)

Implementation activities, inputs and costs

Establishment activities

- The equipment that is needed for planting is collected and prepared; this can include such things as A-frames, spades, and sickles.
- The hillside where the technology is to be implemented is first cleaned and groomed to make way for the new hedgerows.
- Contour lines are demarcated.
- The seeds and/or seedlings are planted along the contour lines.

Establishment inputs and costs per ha (average)

Inputs	Cost (USD)	% met by land user
Labour (10 person days)	27	100%
Equipment	32	100%
Agricultural		
– seeds, seedlings	68	100%
TOTAL	**127**	**100%**

Maintenance/recurrent activities

- The hedgerows are weeded and cleaned to discourage unwanted plants and pests.
- Enrichment planting
- The hedgerows are pruned and the clippings are mulched.
- Manuring

Maintenance/recurrent inputs and costs per ha per year

Inputs	Cost (USD)	% met by land user
Labour (26 person days)	71	100%
Agricultural		100%
– seed, seedlings	34	
– manure	20	100%
TOTAL	**125**	**100%**

Remarks:

- The cost of implementing this technology is dependent on the gradient of the slope (and other geographical features), the local cost of the seeds or seedlings, and the availability of labour.
- All costs and amounts are rough estimates by the technicians and authors. Exchange rate USD 1 = NPR 75 in October 2009
- The technology has a low to average cost for implementation. Locally available seeds and seedlings and locally trained manpower and resources are valuable low-cost inputs for implementation. The technology has a higher likelihood of adoption in some social and physiographic areas, especially where land users can integrate their own expertise with scientific knowledge. Many factors play a role in determining whether the technology is effective and sustainable and whether farmers are willing to adopt it; these include that if the technology is demand driven, it is more likely to be adopted, and if land users can use inexpensive local resources they are more likely to try it.

Assessment

Impacts of the technology

Production and socioeconomic benefits

+ + +	Increased fodder production
+ + +	Increased crop yield
+ +	Reduced need for external agricultural inputs
+ +	Diversification of income sources
+ +	Increased product diversification

Production and socioeconomic disadvantages

− − −	Not suitable for very steep slopes (>30°)
− −	Increased demand for irrigation water
− −	High initial cost
− −	Hedgerows require a long time to become well established

Socio-cultural benefits

+ + +	Improved knowledge of conservation/erosion
+ +	Strengthening of community institutions
+ +	Empowerment of the community
+ +	Improved food security and self-sufficiency (reduced dependence on external inputs)

Socio-cultural disadvantages

none

Ecological benefits

+ + +	Reduced surface runoff
+ + +	Increased biomass and ground cover
+ + +	Increased organic matter in the soil
+ +	Increased moisture in the soil
+ +	Increased plant diversity

Ecological disadvantages

−	Increased competition for water, sunlight, and nutrients
−	Hedgerows provide niches that can harbour pests such as birds, slugs, and rodents.

Off-site benefit

+	Reduced siltation downstream
+	Improved buffering/filtering capacity (by soil, vegetation, wetlands)

Off-site disadvantages

none

Contribution to human wellbeing/livelihood

+ +	The hedgerows provide fodder and forage for animals; selling or bartering fodder helps to diversify food sources for humans and can also be a significant source of income.

Benefits/costs according to the land user

This technology provides diverse benefits in the long run.

Benefits compared with costs	short-term	long-term
Establishment	positive	very positive
Maintenance/recurrent	positive	very positive

Acceptance/adoption:

One quarter of the total land users (about 450 families) in the areas studied adopted this technology voluntarily without any external support.

Concluding statements

Strengths and ➔how to sustain/improve	**Weaknesses** and ➔how to overcome
Effective control of soil erosion on sloping land ➔ This vegetative measure of planting along contour lines can be sustained in the long run by initially selecting species preferred by farmers and by continuing to maintain them.	Hedgerows are difficult to establish on steep slopes and in areas where the soil is dry and degraded ➔ Increase moisture in the soil by mulching the hedges
Improved soil fertility ➔ Hedgerows help to increase soil fertility because they trap water and sediment on the terraces; leguminous hedgerow plants fix nitrogen in the soil and when they are mulched their residues increase organic matter in the soil.	Hedgerows take a long time to establish ➔ Increase the amount of manure (compost, crop residue) added to the hedgerows and add more frequently. Increase the frequency of weeding and cleaning.
Quality fodder and forage production ➔ Hedgerows produce fodder and forage for livestock	It is difficult to establish bio-terraces on steep land ➔ Reduce the spacing between hedgerows and grow tree species. Remember that that this technology is not recommend for very steep slopes
Bioterracing ➔ When leguminous plants with deep roots are used in the hedgerows they help to anchor the edges and over time, as the soil accumulates, bioterraces are established.	High initial cost ➔ Make maximum use of local resources and local labour
High adoption potential ➔ This technology is simple to implement using only local resources and is assured of replication since it was demand driven.	Hedgerows threatened by free grazing of animals ➔ Control grazing in the area

Key reference(s): Regmi, BR; et al. (2004) *Factors responsible for acceptance or rejection of SALT and other technological options suitable for shifting and sloping land cultivation areas*, Technical Paper submitted to Hill Agriculture Research Project (HARP), NARC, Kathmandu, Nepal
Sharma, G; Regmi, BR; Tamang, BB; Shrestha, PK (2008) *A resource book: Integrated hedgerow technology* (in Nepali). Pokhara, Nepal: LI-BIRD
ICIMOD (1999) *Manual on contour hedgerow inter-cropping technology.* Kathmandu, Nepal: ICIMOD
Ya, T; Murray, AB (eds) (2004) *Impact of contour hedgerows: A case study,* Focus on Godavari No 3. Kathmandu, Nepal: ICIMOD
Contact person(s): Gyanbandhu Sharma, Local initiatives for Biodiversity Research and Development (LI-BIRD), P.O.Box No. 324, Gairapatan, Pokhara, Nepal; Email: gsharma@libird.org, www.libird.org, Tel: +977 61 5526834/5535357 (O);+977 9846044871 (M)

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Left: A kiwi orchard. The large kiwi vines grow best when they are supported off the ground; the trellises also make it easier for farmers to pick the fruits when they are ripe. Note the trellis T-bar supports. (Samden Sherpa)
Right: Kiwi plants with fruit (Samden Sherpa)

Kiwi fruit cultivation

Nepal: किवी (ठेकी) फल खेति

Kiwi fruit cultivation on sloping land in the mid-hill areas of Nepal can help prevent soil erosion and is a sustainable land management practice. This high value crop introduces biodiversity and improves livelihoods by providing a source of cash income.

The kiwi fruit is native to China. Previously called Chinese gooseberry, it is now more commonly known by its marketing name of kiwi fruit. Kiwi fruits grow on large vines that are similar to grapevines in their general growth and fruiting habits as well as their training and trellising requirements. The fruit normally ripens within 25 weeks after the flowers first appear. The fruits range in weight from 40 to 90 g and can be picked shortly after the first frost in autumn; after that, they can be kept in cold storage for 4–6 months at °C. Kiwi vines can be grown on a wide range of soil types at elevations ranging from 1000 m to 2500 m. The kiwi plant is dioecious, meaning individual plants are either male or female. Only female plants bear fruit, but only when pollinated by a male plant. Vines of both sexes are essential for fruit production, and they must flower at the same time to ensure pollination. One male pollinator vine is required for eight female vines. The vines are commonly supported on sturdy structures strong enough to bear the heavy fruit, which might otherwise break the rather weak vines. T-bars or hitching post trellises are recommended to support the large fruiting area in the form of a canopy and provide easy access to the fruit.

Seedlings can be planted in the spring as soon as there is little chance of frost. Vines need to be pruned both in summer and in winter to maintain a balance between kiwi plant growth and profitable fruit production. Excessive plant growth is removed during the growing season to keep the kiwi canopy open and to remove non-fruiting wood. Harvesting can begin from the end of November. Frequent weeding is required to reduce competition for moisture and fertilizer. Kiwi fruit requires abundant water; during the dry season the newly planted kiwi vines need deep watering once a week.

WOCAT database reference: QT NEP 30
Location: ICIMOD Knowledge Park at Godavari, Lalitpur District, Nepal.
Technology area: 1 ha
Conservation measure(s): Vegetative
Land Use: Perennial (non-woody) cropping
Stage of intervention: Mitigating land degradation
Origin: Introduced as an experiment (plant origin China)
Climate: Subhumid/temperate
Related approach: Not described
Compiled by: Samden Sherpa, ICIMOD
Date: April 2011, updated March 2013

The technology was documented using the WOCAT (www.wocat.org) tool.

ICIMOD WOCAT

Classification

Land use problems

When sloping land is not used for agricultural production and not planted with ground cover or other vegetation (such as contour hedgerows), the fertile soil can be eroded and washed away by heavy monsoon rains.

Land use

Perennial (non-woody) cropping (rainfed)

Climate

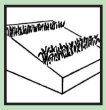
Subhumid/temperate

Degradation

Loss of topsoil by water erosion

Nutrient depletion and reduced fertility by overuse of chemical fertilizers

Conservation measures



Vegetative: planting of kiwi fruit with hedegrows

Stage of intervention

- Prevention
- Mitigation/reduction
- Rehabilitation

Origin

- Land users' initiative
- Research: demonstration
- Externally introduced
- Other (specify)

Level of technical knowledge

- Low
- Medium: some technical knowledge needed
- High

Main causes of land degradation: Soil erosion and nutrient depletion can occur on sloping land when there is insufficient ground cover.

Technical function/impact

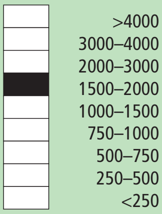
Main:
- Improves ground cover
- Reduces soil erosion
- Increases soil fertility
- Increases biomass production

Secondary:
- Reduces gradient
- Controls erosion
- Retards runoff

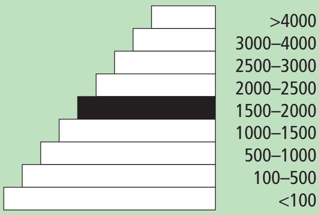
Environment

Natural environment

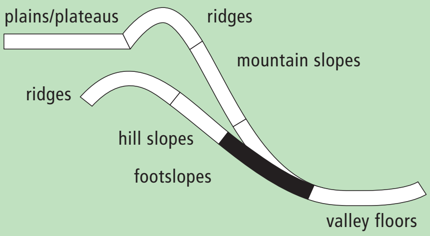
Average annual rainfall (mm)



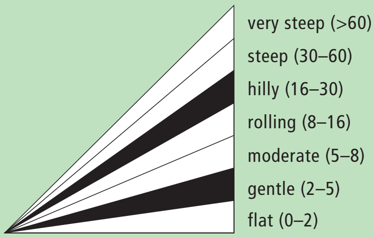
Altitude (masl)



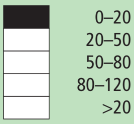
Landform



Slope (%)



Soil depth (cm)



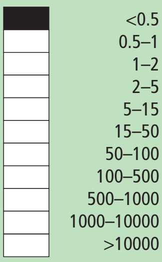
Growing season(s): two
Soil texture: medium loam
Soil fertility: medium
Topsoil organic matter: high (>3%)
Soil drainage/infiltration: medium
Soil water storage capacity: medium

Ground water table: <5 m
Availability of surface water: good
Water quality: good for drinking and agricultural use
Biodiversity: high (695 species of flora and 230 species of fauna have been documented within the Knowledge Park's 30 ha area)

Tolerant of climatic extremes: mild winter frost and heavy rainfall events
Sensitive to climatic extremes: sustained heat spells, strong winds, hail and dust storms; seedlings are susceptible to drought
If sensitive, what modifications were made/are possible: a net canopy can be used to protect the vines from hail storms and help prevent fruit from dropping prematurely

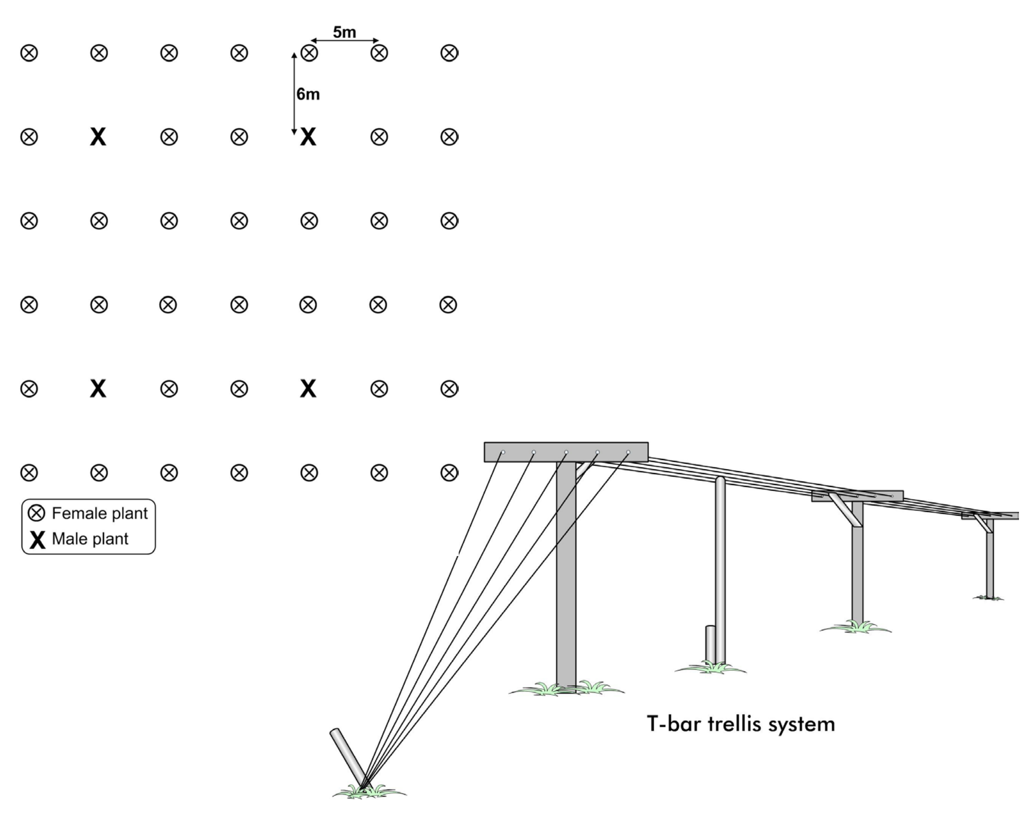
Human environment

Crop land per household (ha)



Land user: for demonstration and experiment
Population density: >10 persons per km^2
Land ownership: government
Land/water use rights: community/individual
Relative level of wealth: neighbouring communities are poor
Importance of off-farm income: >50% of all households around the demonstration site have off-farm income
Access to services and infrastructure: labour available; road access used to transport crops

Market orientation: mixed subsistence and commercial in the vicinity of the demonstration site
Mechanization: manual and animal traction
Number of livestock: in the vicinity of the demonstration site poor households may have a few goats whereas wealthier farmers often own several cattle
Purpose of forest/woodland use: fodder, fuelwood
Types of other land: scrubland
Level of technical knowledge required: medium for farmers and technicians, some training is required



Establishing a kiwi orchard
Above: Layout of a kiwi orchard. The ideal density of kiwi plants in an orchard is 300 per ha, or in terms of the units of measure commonly used in Nepal, 15 plants per ropani. The plants are spaced 6 m apart and the distance between the rows is 5 m, with a male to female plant ratio of 1:8.
Below: T-bars are used as trellis supports for the kiwi vines. The T-bars are 2.5–3 m long iron posts that are anchored into the ground; they extend approximately 1.8 m above the ground and 60–70 cm deep into the soil. The arms of the T-bar extend 1–1.2 m. The bars are spaced approximately 4.5 m apart with galvanized wire strung between them and pulled taught to form the trellis itself. The end posts are braced by 4–5 wires that are secured into the ground (as shown).
The kiwi plants should be at least 0.6 m away from the T-bars. The centre wire supports the main cordons, and the outer wires support the fruiting lateral parts.
(AK Thaku)

Implementation activities, inputs and costs

Establishment activities

Vegetative:

- The plot where the vines are to be planted is prepared by clearing and weeding.
- The seedling pits are prepared at least 2 months before planting. Typically the pits are 1 m x 1 m and 1 m deep. The pits are filled with compost (30 kg per pit) and covered with soil to a height of 0.3 m above the ground.
- Seedlings are planted in the winter to the same depth as in the nursery; they are planted 6 m apart in rows spaced 5 m apart.
- The plants are pruned back to single, healthy shoots 15–30 cm high.

Structural:
Details of the T-bar trellises are given in the diagram.

Establishment inputs and costs per ha (average)

Inputs	Cost (USD)	% met by land user
Labour (136 person days)	500	
Equipment		
– Iron poles	3500	
Materials		
– Planting materials	1500	
Agricultural		
– Compost/farmyard manure	150	
TOTAL	**5650**	**0%**

Maintenance/recurrent activities

- Permanent sod is maintained between the plant rows. Frequent weeding is required especially during the rainy season.
- Both summer and winter pruning is required.
- Cuttings from branches that fruited during the previous season (typically less than a pencil width in thickness) are collected during the winter pruning for propagation.
- Overhead sprinkler irrigation is used for commercial kiwi production.
- Kiwi vines are fertilized with manure in the early spring

Maintenance/recurrent inputs and costs per ha per year*

Inputs	Cost (USD)	% met by land user
Labour (122 person days)	450	
Equipment		
– Secateurs	50	
Materials		
– Binding wire	650	
Agricultural		
– Compost	150	
TOTAL	**1300**	**0%**

Remarks:

- *The above establishment cost is for a plantation of 300 plants on one hectare; the recurrent annual maintenance cost has been calculated for a plantation of 300 plants per ha per year. All costs are estimated based on experience gained at the ICIMOD Knowledge Park at Godavari.
- All costs and amounts are rough estimates by the technicians and authors. Exchange rate USD 1 = NPR 71 in April 2011

Assessment

Impacts of the technology

Production and socioeconomic benefits
- +++ Reduced downstream flooding
- +++ Improved buffering/infiltration capacity

Production and socioeconomic disadvantages
- −− Increased demand for irrigation

Socio-cultural benefits
- +++ Strengthened community institution; increased income
- +++ Improved knowledge of land management with kiwi fruit cultivation

Socio-cultural disadvantages
- −− Kiwi fruit is considered an elite fruit and it is usually too expensive for local consumption

Ecological benefits
- +++ Improved ground cover
- +++ More efficient use of land
- +++ Reduced soil erosion
- +++ Mixed farming (enhanced biodiversity)
- +++ Pollen for bees

Ecological disadvantages
- −− Increased competition with other plants for water, nutrients, and sunlight when intercropping

Off-site benefit
- +++ Reduced soil erosion
- +++ Increase biomass production

Off-site disadvantages
- none

Contribution to human wellbeing/livelihood
- +++ Kiwi production can be a good source of cash income as it is a high value crop. Kiwi fruit is high in nutrients, eating kiwis has been show to boost the immune system, to help regulate blood pressure, and to be beneficial for cardiac patients.

Benefits/costs according to the land user

The approximate annual income from kiwi production is USD 11,765/ha/year. The technology provides on-farm employment opportunities for both men and women.

Benefits compared with costs	short-term	long-term
Establishment	positive	very positive
Maintenance/recurrent	slightly positive	very positive

Acceptance/adoption:
Kiwi fruit is gaining in popularity in Nepal; at present it is cultivated commercially by farmers in Kavre, Lalitpur, Dolakha, and Ilam Districts as well as in the Kathmandu Valley. The technology is widely accepted. Kiwi saplings were initially supplied by ICIMOD and by a private nursery in Kavre District.

Driver for adoption:
- Increased market demand for kiwi fruit
- A good alternative for sloping land management
- Kiwi cultivation is a source of income generation

Constraints
- It has been difficult to meet the high demand for kiwi seedlings. The scarcity of seedlings is the main bottleneck limiting the uptake of kiwi production.

Concluding statements

Strengths and ➔how to sustain/improve	**Weaknesses** and ➔how to overcome
Orchards are easy to establish and farmers can readily learn what is needed for kiwi cultivation ➔ Awareness and training programmes can help farmers quickly learn what is needed for kiwi cultivation.	The initial costs associated with establishing the orchard may be a little expensive for many farmers, these include the purchase of: T-bar trellises, seedlings, iron rods, and wire. ➔ Begin by using locally available materials such as bamboo poles to make T-bar trellis.
The benefits of the technology are easy to observe; farmers generate cash income from selling kiwi fruit, juice, and jam. ➔ Awareness and training programmes can help farmers quickly learn what is needed for kiwi cultivation and postharvest processing.	
Soil erosion is decreased due to increased groundcover. ➔ Awareness and training programmes can help farmers quickly learn what is needed for kiwi cultivation.	
Kiwi cultivation provides on-farm employment opportunities. ➔ Awareness and training programmes can help farmers quickly learn what is needed for kiwi cultivation.	

Key reference(s): Himelrick, DG; Powell, A (1998) *Kiwi fruit production guide*. Tuscaloosa, Alabama, United States: Alabama University http://www.aces.edu/pubs/docs/A/ANR-1084/ANR-1084.pdf (accessed 11 November 2012)
Thapa, DB (2009) Kiwi fruit culture. Kirtipur, Nepal: Horticultural Office
Contact person(s): Mr Samden Lama Sherpa, ICIMOD, P.O.Box 3226, Kathmandu, Nepal; Tel: +977 1 5003222; Email: ssherpa@icimod.org
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Left: Method #1 The ridge is covered by a plastic film and broad leaf mustard seedlings are planted into the ground through regular holes punched into the plastic. (KM Sthapit)
Right: Method #2 Chilli seeds are planted directly in the ground, when the seedlings are a few centimetres high the entire ridge is covered by a plastic film and holes are punched into the plastic allowing the seedlings to emerge. Unwanted weeds are left under the film. (KM Sthapit)

Plastic film technology

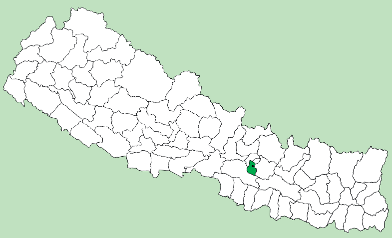
Nepal: प्लाष्टिक प्रयोग गरी खेति गर्ने प्रबिधि

Plastic film technology, sometimes called plastic mulching, is an important breakthrough that can transform traditional agriculture into modern agriculture by helping to circumvent many of the limitations of temperature and moisture. Plastic film is used to cover the surface of the soil in order to increase the temperature, to retain moisture, and to promote the germination of seeds.

Agricultural production by traditional methods is constrained by extremes in temperature and by extremes in the availability of water; freezing temperatures as well as droughts and waterlogging have long daunted farmers. When plastic film is used on the soil, the solar energy absorbed by the soil during the day is retained at night since the plastic film prevents water from evaporating. Higher night time temperatures and higher levels of moisture in the ground promote active micro-organisms, which diminish the need for fertilizer and improve the physical properties of the soil.

Plastic film can be used in one of two ways. In the first method, the plastic film is spread on ridges of soil, the plastic is perforated at regular intervals, and the seedlings are planted through these openings. In the other method, seeds are planted on the ridges as in the traditional method, and when the seedlings have grown to a reasonable size, the ridge is covered by a plastic film and holes are cut at the position of the seedlings to allow them to pass through the film. Depending on the condition of the film after the crops are harvested, the covered ridges can be used to grow another crop.

Experiments at ICIMOD show that the use of plastic film can, on average, double the crop yield as compared to traditional methods. Previous studies by Lu Rongsen (1994) showed that the plastic film method can increase chilli production by 74%, tomato production by 52%, and the production of garden peas by 31%.



WOCAT database reference: QT NEP 37
Location: ICIMOD Knowledge Park at Godavari, Lalitpur District, Nepal.
Technology area: Demonstration plot
Conservation measure(s): Agronomic
Land Use: Cropland
Stage of intervention: Mitigation
Origin: Experiment and research
Climate: Subhumid/temperate
Related approach: Not described
Compiled by: Samden Sherpa, ICIMOD
Date: June 2011, updated March 2013

The technology was documented using the WOCAT (www.wocat.org) tool.

ICIMOD WOCAT

Classification

Land use problems

Farmers have traditionally used mulching to retain moisture in the soil and to help plants withstand ground frost. Mulching is useful but has many limitations. Recently, plastic film technology has been successfully introduced to help retain moisture in the soil and to promote seed germination. Since moisture is retained, the temperature of the soil does not drop as low as it would otherwise; this accelerates the growth and the development of both the roots and the whole plant, resulting in good crops and high yields.

Land use

Annual crop

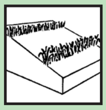
Climate

Subhumid/ temperate

Degradation

Water degradation: aridification/ soil moisture problems

Conservation measures



Management: Conservation of soil moisture and weed control

Stage of intervention

- □ Prevention
- ■ Mitigation/reduction
- □ Rehabilitation

Origin

- □ Land users' initiative
- ■ Research: demonstration
- □ Externally introduced
- □ Other (specify)

Level of technical knowledge

- □ Low
- ■ Medium: farmers
- □ High

Technical function/impact

Main:
- Increases the temperature of the soil
- Retains soil moisture
- Reduces soil erosion
- Promotes seed germination and emergence

Secondary:
- Accelerates the growth and development of roots and plants in areas where the temperature is low during winter
- Hastens maturation of crops
- Increases yield and promotes good quality crops

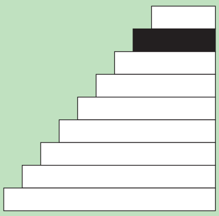
Environment

Natural environment

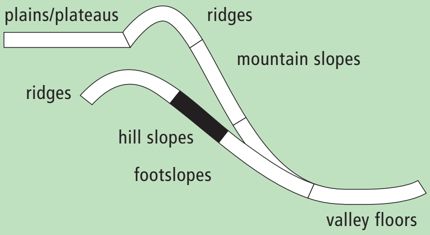
Average annual rainfall (mm)

- □ >4000
- □ 3000–4000
- □ 2000–3000
- ■ 1500–2000
- □ 1000–1500
- □ 750–1000
- □ 500–750
- □ 250–500
- □ <250

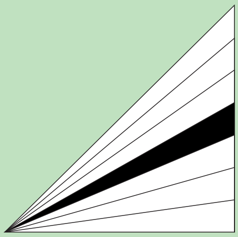
Altitude (masl)



Landform



Slope (%)



Soil depth (cm)

- ■ 0–20
- □ 20–50
- □ 50–80
- □ 80–120
- □ >20

Growing season(s): two
Soil texture: medium loam
Soil fertility: medium
Topsoil organic matter: high (>3%)
Soil water storage capacity: medium
Ground water table: <5 m
Availability of surface water: good

Water quality: good for drinking and agricultural use
Tolerant of climatic extremes: plants grown using plastic film technology can tolerate long spells of low temperature in winter, as well as frost and snowfall
If sensitive, what modifications were made/ are possible: none

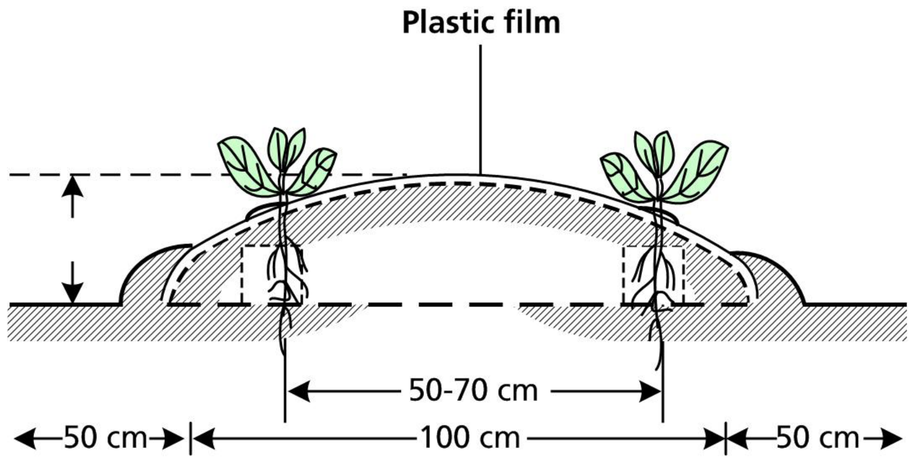
Human environment

Crop land per household (ha)

- ■ <0.5
- □ 0.5–1
- □ 1–2
- □ 2–5
- □ 5–15
- □ 15–50
- □ 50–100
- □ 100–500
- □ 500–1000
- □ 1000–10000
- □ >10000

Land user: for demonstration and experiment
Population density: >2 persons per km^2
Land ownership: government
Land/water use rights: community/individual
Relative level of wealth: neighbouring communities are poor
Importance of off-farm income: >50% of all households around the demonstration site have off-farm income
Access to services and infrastructure: labour available; road access used to transport crops

Market orientation: mixed subsistence and commercial in the vicinity of the demonstration site
Mechanization: manual and animal traction
Number of livestock: in the vicinity of the demonstration site poor households may have a few goats whereas wealthier farmers often own several cattle
Purpose of forest/woodland use: fodder, fuelwood
Types of other land: scrubland
Level of technical knowledge required: medium, some training required



Technical drawing
The diagram shows a cross-section of a ridge planted using plastic film technology. The plants grow through holes punched in the plastic. The plastic helps to retain moisture in the soil and, in so doing, also helps to increase the soil temperature. Weeds trapped below the plastic are inhibited from interfering with the crop.
The ridges (or beds) are typically 20 m long, 1 m wide and spaced 1 m apart (for access); they are usually 10–20 cm high. The distances shown in the diagram are averages for crops such as chillies where the row-to-row distance is 50–70 cm and the plant-to plant distance is 40–50 cm. These distances vary according to the crop.
(AK Thaku)

Implementation activities, inputs and costs

Establishment activities

The plot of land to be planted is prepared by first fertilizing it with a mixture of soil, compost, and/or farmyard manure. The soil is gathered into parallel ridges, typically 20 m long, 1 m wide, and 10–20 cm high; the distance between two ridges is usually 40–50 cm. For many crops the seedlings are spaced 50–70 cm apart.
Method #1 Plastic film (approx. thickness 0.014–0.003 mm) is used to cover the ridges and anchored into the ground. Round holes are punched in the film at regular intervals. Some soil is excavated through the holes and the seedlings are planted through the holes and thoroughly watered. The holes in the plastic are sealed using soil.
Method#2 Seeds are sown on the ridges and seedlings are allowed to develop. The ridge is covered in plastic film and the film is anchored. Holes are punched into the plastic at the position of the seedlings so that they pass through.
For either method, when the crops are harvested all residue should be removed. Depending on local conditions and on whether the plastic film is still viable, the plastic covered ridges can be reused to grow another crop without replacing the film.

Establishment inputs and costs per ha

Inputs	Cost (USD)	% met by land user
Labour (80 person days)	310	
Equipment		
– Spade, secateurs	10	
Materials		
– Plastic film (48 kg/ha)	48	
Agricultural		
– Seedlings/compost	250	
TOTAL	**668**	0%

Maintenance/recurrent activities

Provide crop support such as staking and removal of excess leaves as required.

Maintenance/recurrent inputs and costs per ha per year

Inputs	Cost (USD)	% met by land user
Labour (30 person days)	110	
Materials		
– Bamboo poles	20	
TOTAL	**130**	**0%**

Remarks:

- All costs and amounts are rough estimates by the technicians and authors. Exchange rate USD 1 = NPR 72 in June 2011.
- This was a demonstration project conducted by ICIMOD.

Assessment

Impacts of the technology

Production and socioeconomic benefits

+++ Increased crop yield in areas with a long winter season
+++ Reduced soil erosion and nutrient loss
+++ Greater farm income; less time is spent weeding

Production and socioeconomic disadvantages

none

Socio-cultural benefits

+++ Improved understanding of how to maintain soil fertility, how to conserve water, and why soil erodes

Socio-cultural disadvantages

none

Ecological benefits

+++ Reduced soil erosion
+++ Increased moisture in the soil
+++ Increased soil temperature
+++ Weeds are controlled

Ecological disadvantages

−− The discarded plastic is not biodegradable.

Off-site benefit

+ Downstream farmers benefit because soil is conserved and runoff is reduced.

Off-site disadvantages

− If farmers do not dispose of old plastic film responsibly it can become a nuisance even far from where it was originally used.

Contribution to human wellbeing/livelihood

+++ Improved crops and higher yields benefit the entire community because more food is available and the harvest brings in cash income.

Benefits/costs according to the land user

The above example shows that the establishment and maintenance cost for 1 ha of land is USD 798. Using plastic film technology this 1 ha of land yielded USD 1500 worth of crops.

Benefits compared with costs	short-term	long-term
Establishment	positive	very positive
Maintenance/recurrent	very positive	very positive

Acceptance/adoption:
This demonstration of plastic film technology was used mainly to show that it is viable both in the mid-hills and at higher elevations where temperatures can be very low during the winter season. Plastic film technology can be used to cultivate high-value horticultural crops such as vegetables, strawberries, and melons. In China, it has been successfully used to cultivate more than 80 species (Lu Rongsen 1994).

Driver for adoption:
Improved income for farmers and less time is spent weeding. Greater awareness among farmers is being spread through participatory research and development in rural areas.

Constraints
Plastic film is not always available in rural areas

Concluding statements

Strengths and ➔how to sustain/improve	**Weaknesses** and ➔how to overcome
Plastic film technology can increase the yield of some crops by as much as 100% as compared to conventional farming. ➔ Since this technology is still relatively new, it will be necessary to continue sharing experiences and to promote awareness.	As farmers begin to use plastic film technology more plastic is being discarded in rural areas. ➔Plastic film needs to be retrieved and recycled. In China it has been shown that this is possible.
Plastic film technology can be used to grow crops in hilly areas where the long winter season is usually too cold to support crops. ➔ Need to create greater awareness of the benefits of using plastic film technology in mountain areas.	Discarded plastic film can pollute agricultural lands ➔Farmers need to be made aware of hazards and encouraged to form networks for collection and recycling the used plastic.

Key reference(s): Rongsen, L (1994) *The application of plastic film technology in China: Plastic film technology data collected and analyzed in ICIMOD D&T Centre, Godavari.* Kathmandu, Nepal: ICIMOD
Contact person(s): Mr Samden Lama Sherpa, ICIMOD, P.O.Box 3226, Kathmandu, Nepal; Tel: +977 1 5003222; Email: ssherpa@icimod.org
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Left: This open-sided polyhouse is constructed using local materials; it is a low cost solution used to grow tomatoes during the rainy season. (SSMP)
Right: Harvesting off-season tomatoes from a polyhouse. (SSMP)

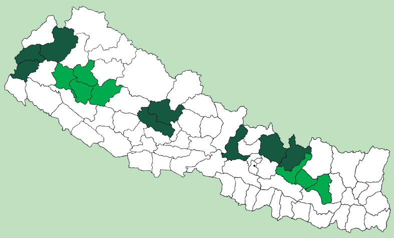
A low-cost polyhouse for tomato production in the rainy season

Nepal: सस्तो प्लाष्टिक घरमा वर्षे गोलभेडा खेति

Smallholder farmers can use polyhouses to produce high demand vegetables, such as tomatoes, and can earn a substantial income from even a relatively small plot of land in a short time.

During the wet season (June–October), the monsoon rains severely limit the type of crops that can be grown in open fields and they also restrict the production of seedlings. Low-cost polyhouses can be used to protect crops from excessive rainfall and can provide a sheltered environment for the production of better quality crops over the rainy season cropping period. For example, smallholder farmers who produce high demand vegetables such as tomatoes can earn as much as USD 350–500 from a plot of land which measures only 100 m^2 in area over the short time period from June to November. This is much more than they can earn by growing any traditional crop by conventional methods. The Sustainable Soil Management Programme (SSMP) is promoting this technology in several mid-hill districts of Nepal.

Polyhouses should be situated in well-drained areas where sunshine is abundant and there is no shade throughout the cropping period. The bamboo frame can be constructed earlier in the year but the plastic roofing is not added until after one or two rainfall events. The height of the polyhouse frame varies depending on the altitude. At higher elevations, the polyhouses are lower to help trap more heat and moisture, whereas at lower elevations the polyhouses are higher to allow more air to circulate and moisture to evaporate. The preparations, which take place mid-May to early June, consist of fertilizing the soil and planting the tomato seedlings. Throughout the growing season the tomato plants are staked, trained, and pruned and a top dressing of fertilizer is added to produce a higher quality product.



WOCAT database reference: QT NEP 31
Location: Nepal mid-hills
Technology area: Sustainable Soil Management Programme (SSMP) implements its programmes in several mid-hill districts of Nepal. The map above shows districts where they have worked in the past (dark green) and where they worked in 2011 (light green).
Conservation measure(s): Agronomic
Land Use: Annual cropping (rainfed)
Stage of intervention: Prevention of land degradation
Origin: Introduced through projects
Climate: Humid/subtropical
Related approach: Farmer-to-farmer diffusion (QA NEP 1) and Farmer-led experimentation (QA NEP 3)
Compiled by: Bishnu Kumar Bishwakarma, SSMP and Helvetas Nepal
Date: April 2011, updated March 2013

The technology was documented using the WOCAT (www.wocat.org) tool.

ICIMOD HELVETAS Swiss Intercooperation NEPAL WOCAT

Classification

Land use problems

In the mid-hills of Nepal, the arable land of most farm households has been divided into very small plots. If this land is used to produce traditional crops such as maize, wheat, and millet using conventional farming methods, it cannot provide full employment for all of the householders and cannot yield sufficient cash income for the household. The risk of intense rainfall during the monsoon season, which can damage crops, has prevented these farmers from switching to more lucrative high value crops.

Land use

Annual crops; maize, wheat, vegetables

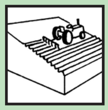
Climate

Humid/ subtropical

Degradation

Land and crops can be damaged by heavy rainfall events during monsoon

Conservation measures



Agronomic: introduction of a new crop

Stage of intervention

Prevention
Mitigation/reduction
Rehabilitation

Origin

Land users' initiative
Experiments/research
Externally introduced: project
Other (specify)

Level of technical knowledge

Low
Medium: land users
High

Main causes of land degradation: During the summer monsoon (June-October), continuous or heavy rainfall can damage seedlings and erode the land; it is difficult to establish crops during this time.

Technical function/impact

Main:
- Increases productivity
- Introduces a high value crop

Secondary:
- Improves nutrition

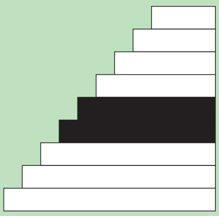
Environment

Natural environment

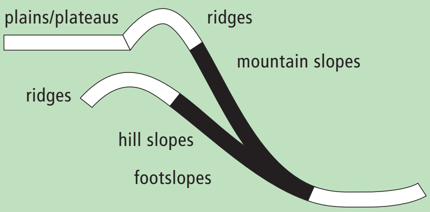
Average annual rainfall (mm)

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

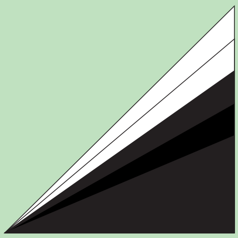
Altitude (masl)



Landform



Slope (%)



Soil depth (cm)

0–20
20–50
50–80
80–120
>20

Growing season(s): one (May to November)
Soil texture: medium
Soil fertility: medium to high
Topsoil organic matter: medium to high
Soil water storage capacity: medium to good
Tolerant of climatic extremes: heavy rainfall

Sensitive to climatic extremes: high temperatures and high relative humidity
If sensitive, what modifications were made/ are possible: optimize the plant density; train and prune plants often to avoid overcrowding; modify the structure to provide more ventilation (ventilated polyhouse) in especially hot areas

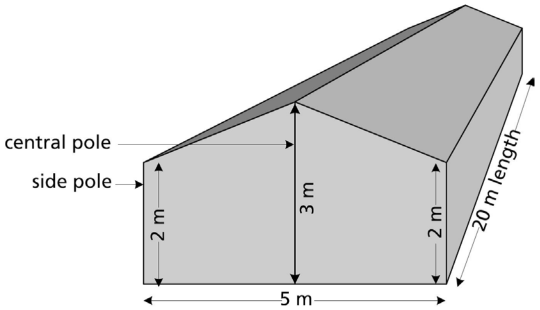
Human environment

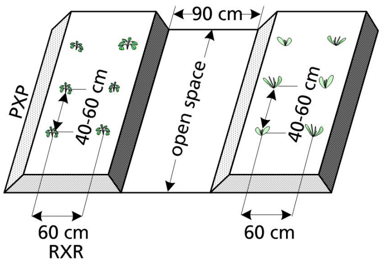
Crop land per household (ha)

<0.5
0.5–1
1–2
2–5
5–15
15–50
50–100
100–500
500–1000
1000–10000
>10000

Land user: individual, leased
Land ownership: individually owned, titled and not titled
Land/water use rights: individual (land) and communal (organized)
Importance of off-farm income: in most farm households, off-farm income plays only a minor role. Occasional opportunities for off-farm income present themselves in the form of daily wage labour. Some households receive remittances from family members working abroad.

Market orientation: commercial
Mechanization: manual and animal traction





Technical drawing
Left: Sketch of a polyhouse. The optimum length is 20 m and the width 5 m. The height of the central and side poles varies depending on the elevation. Note that there should be a space of at least 1 m between polyhouses.

Right top: Cross sectional view of a planting bed showing row-to-row (RXR) and plant-to-plant (PXP) distances. Note that there should be a space of at least 90 cm between beds.

Right bottom: Inside the polyhouse, the tomatoes can be staked using bamboo poles; the plants are trained along these trellises.
(AK Thaku)

Implementation activities, inputs and costs

Establishment activities

1. Construction of the polyhouse using bamboo poles, wooden posts, clear plastic sheet, nails, and rope.
2. How long it takes to construct the polyhouse and plant the crops depends on how much labour is available. Depending on their level of expertise, four to five people can construct the structure in one day; and two people can complete the soil preparation and planting in one day.

Technical guidelines for erecting a polyhouse

The optimum length of a polyhouse is 20 m, and the width is 5 m; 400–500 gauge plastic sheeting is used. The height of the polyhouse depends on the elevation: at 1200–1600 masl, the optimum height of the central pole is 3 m and the side poles are 2 m high; at 1600–2000 masl, the central pole is 2.5 m high and the side poles are 1.6 m high. There should be an open space of at least 1 m between polyhouses.

Technical guidelines for preparing the soil and planting tomatoes

Per plant, at least 3–4 kg of well-decomposed farmyard manure and compost are worked into the soil. Before transplanting the seedlings, the soil around each is dressed with 10 g of DAP (diammonium phosphate) and 6 g of MoP (muriate of potash). The seedlings are transplanted when they are 20–25 days old. In an open row system, the suggested row to row (RxR) spacing is 90 cm and the suggested plant to plant (PxP) spacing is 60 cm; in a closed row system the row to row and plant to plant spacing can both be 60 cm.

At least two top dressings of DAP and MoP (10:10 g) are necessary 20–25 and 40–45 days after transplanting; 1 kg per 0.05 ha of borax is also added at the time of the first top dressing. Alternatively, these two top dressings can be substituted by a mixture of cattle urine (50 ml) and water (200 ml water) per plant. The dressing with this mixture can begin 20–25 days after transplanting, and is repeated every 10–12 days.

Establishment inputs and costs per poly house

Inputs	Cost (USD)	% met by land user
Labour		
– construction of polyhouse (5 person days)	15–20	100%
– planting, training, pruning, staking	15–20	100%
Materials		
– Bamboo or /wooden poles, plastic sheeting, rope, nails, seeds, poles for staking	80–90	35%
Agricultural		
– Seeds, fertilizers, crop protection	7–10	50%
TOTAL	**117–140**	**71%**

Maintenance/recurrent activities

There are no major maintenance costs during the cropping season; but occasionally some minor maintenance is required (e.g., replacing damaged stakes and plastic sheet, or securing with additional rope and nails).

Maintenance/recurrent inputs and costs per poly house per year

Inputs	Cost (USD)	% met by land user
Labour (1 person day)	5	100%
Equipment	5	100%
Materials	10	100%
Agricultural	5	100%
TOTAL	**25**	**100%**

Remarks:
- All costs and amounts are rough estimates by the technicians and authors. Exchange rate USD 1 = NPR 71 in April 2011

Assessment

Impacts of the technology

Production and socioeconomic benefits

+ + +	Reduced risk of crop failure
+ + +	Increased on-farm income
+ +	Diversification of income sources
+ +	Increased crop diversification

Production and socioeconomic disadvantages

− −	Set-up cost is high
− −	Labour intensive
− −	Some technical know-how is needed

Socio-cultural benefits

+ + +	Improved situation of socially and economically disadvantaged groups
+ + +	Improved food security and reduced need for either seasonal migration or outside help

Socio-cultural disadvantages

none

Ecological benefits

+ + +	Reduced danger of crops being affected by hazards and extreme events (heavy rainfall, drought)
+	Reduced soil loss

Ecological disadvantages

−	Can be susceptible to some fungal diseases

Off-site benefit

+ +	Areas downstream benefit from soil retention

Off-site disadvantages

− −	Carelessly discarded plastic sheeting can be an environmental nuisance

Contribution to human wellbeing/livelihood

+ + +	This technology provides employment and income opportunities to smallholder farmers; improved economic situation leads to overall livelihood improvement

Benefits/costs according to the land user

Benefits compared with costs	short-term	long-term
Establishment	positive	positive
Maintenance/recurrent	positive	positive

Acceptance/adoption:
Although the technology is only moderately expensive to implement and provides a higher rate of return than traditional crops, smallholder farmers often need technical support and encouragement to get started. This support can be in the form of improved seed varieties and plastic sheeting for the polyhouse.

Driver for adoption:
- relatively simple technology
- higher economic return
- provides on-farm employment

Constraints
- smallholder farmers and poorer households need initial support to establish the polyhouse
- farmers need technical support
- farmers need practical information and technical backstopping

Concluding statements

Strengths and ➔how to sustain/improve	**Weaknesses** and ➔how to overcome
Cost effective in terms of output as compared to traditional crops ➔ Identify other cash crops that can also provide improved income opportunities	Need to provide training and technical know-how and need on-farm research to identify alternative cash crops ➔ Farmer-to-famer extension can help to identify other crops
This technology can be integrated to make maximum use of farm niches; it is especially beneficial for smallholder farmers ➔ Provide training on the construction of polyhouses to experienced lead farmers so that they can provide technical support to others.	Vulnerable to diseases and pests ➔ Adjust planting time to local conditions; build the polyhouses in appropriate locations; plant resistant varieties; modify the structure to improve air circulation; prune and train plants throughout the cropping season; improve staking techniques; rotate crops or move polyhouse every three years
It mostly uses local materials ➔ Ensure bamboo poles are available on the farm; encourage the use of silpaulin which is more durable than polyethylene	Some initial set-up cost ➔ Silpaulin can be purchased at lower cost when farmers' groups buy in bulk.
Uses local expertise, farmer knowledge, and practices ➔ Farmers can make the most of their investment by linking with markets and by providing support for value chain development.	

Key reference(s): SSMP (2010) *Construction of polyhouse and rainy season tomato cultivation inside polyhouse* (in Nepali). Kathmandu, Nepal: Sustainable Soil Management Programme, Helvetas Nepal

Contact person(s): Team Leader, Sustainable Soil Management Programme (SSMP), GPO Box 688, Kathmandu/Nepal, Tel:+977 1 5543591, ssmp@helvetas.org.np; or Bishnu Kumar Bishwakarma, bishnu.bishwakarma@helvetas.org.np; Tel: 9851133479 (M), +977 1 5543591 (O)

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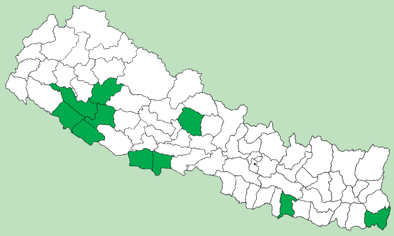
Left: Man operating a treadle pump (Purusottam Gupta).
Right: : A woman using a treadle pump to irrigate a paddy field. (Purusottam Gupta).

Treadle pump

Nepal: लक्ष्मी ढिकी पम्प

A treadle pump is a foot operated water lifting device that can be used by smallholder farmers to irrigate their land in places where the water table is high.

A treadle pump is a simple, cheap, and effective device for lifting water. In this technology, bamboo levers are pushed repeatedly by foot to provide the driving power to lift water. This simple device is relatively easy to install and maintain and is environmentally friendly. Three types of treadle pumps are in common use; all three use the cylinder and paddle concept, but the model which uses a cylinder 8.9 cm in diameter and has bamboo paddles is the one most commonly favoured by farmers in the region. It is cheaper and can lift more water than a comparable hand pump. On average, a treadle pump can be used to lift water from about 6 m underground and one such pump can irrigate as much as 0.34 ha of land (depending on the soil type and other conditions). In addition to lifting water for irrigation, the treadle pump can also be used for a variety of domestic purposes. In the Terai areas of Nepal, it is also widely used as a means of generating income. When farmers consider installing a treadle pump, they first need to verify whether there is sufficient groundwater to merit the expense. Treadle pumps should be installed by trained technicians and properly maintained throughout their lifetime. If possible, an extra set of spare parts should always be kept on hand and a trained technician should be consulted for major repairs.



WOCAT database reference: QT NEP 32
Location: Banke, Bardiya, Dailekh, Surkhet, Kaski, Dhanusha, Kapilbastu, Rupandehi, Jhapa, and Salyan Districts, Nepal.
Technology area: >1,000 km^2
Conservation measure(s): Structural
Land Use: Annual cropping
Stage of intervention: Prevention of land degradation
Origin: Experiment/research
Climate: Subhumid/subtropical
Related approach: Not described
Compiled by: Purusottam Gupta, IDE-Nepal
Date: May 2011, updated March 2013
General comments: This technology is used by more than one and half million people in different countries including Bangladesh, Cambodia, India, and Nepal. More than thirty thousand people have treadle pumps in Nepal. Treadle pumps are also a useful means of generating income for smallholder farmers in the Terai area of Nepal.

The technology was documented using the WOCAT (www.wocat.org) tool.

ICIMOD iDE नेपाल Nepal WOCAT

Classification

Land use problems

Most agriculture in Nepal is rainfed. There is a general scarcity of water for irrigation and the availability of the water that exists is limited by economic and energy constraints.

Land use

Annual cropping (rainfed)

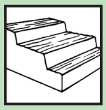
Climate

Subhumid/ subtropical

Degradation

Water degradation: soil moisture problem

Conservation measures



Structural

Stage of intervention

- ■ Prevention
- □ Mitigation/reduction
- □ Rehabilitation

Origin

- □ Land users' initiative
- □ Experiment/research: IDE-Nepal
- ■ Externally introduced
- □ Other (specify)

Level of technical knowledge

- □ Low: land users
- ■ Medium: field technicians
- □ High

Main causes of land degradation: water is not available for irrigation, soil moisture is decreasing, crop productivity is declining

Technical function/impact

Main:
- Increases and helps to maintain water stored in soil
- Increases the supply of water

Secondary:
- Improves top soil
- Improves subsoil
- Spreads water

Environment

Natural environment

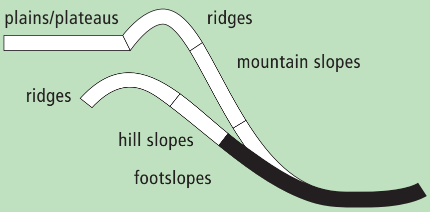
Average annual rainfall (mm)

- □ >4000
- □ 3000–4000
- □ 2000–3000
- □ 1500–2000
- ■ 1000–1500
- □ 750–1000
- □ 500–750
- □ 250–500
- □ <250

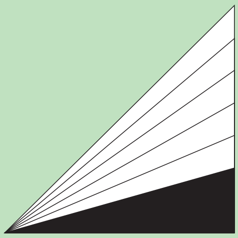
Altitude (masl)

- □ >4000
- □ 3000–4000
- □ 2500–3000
- □ 2000–2500
- □ 1500–2000
- ■ 1000–1500
- □ 500–1000
- □ 100–500
- □ <100

Landform



Slope (%)



Soil depth (cm)

- □ 0–20
- □ 20–50
- □ 50–80
- □ 80–120
- ■ >20

Growing season(s): two
Soil texture: medium (loam)
Soil fertility: medium
Topsoil organic matter: medium
Soil drainage/infiltration: good

Soil water storage capacity: high
Groundwater table: 5–50 m
Availability of surface water: poor
Water quality: for agricultural use only
Biodiversity: medium

Tolerant of climatic extremes: seasonal extremes in rainfall, wind storms, and dust storms
Sensitive to climatic extremes: droughts, dry spells, and floods
If sensitive, what modifications were made/are possible: a larger bore (12.7 cm) treadle pump can be used to access deeper in the water table where more water may be available

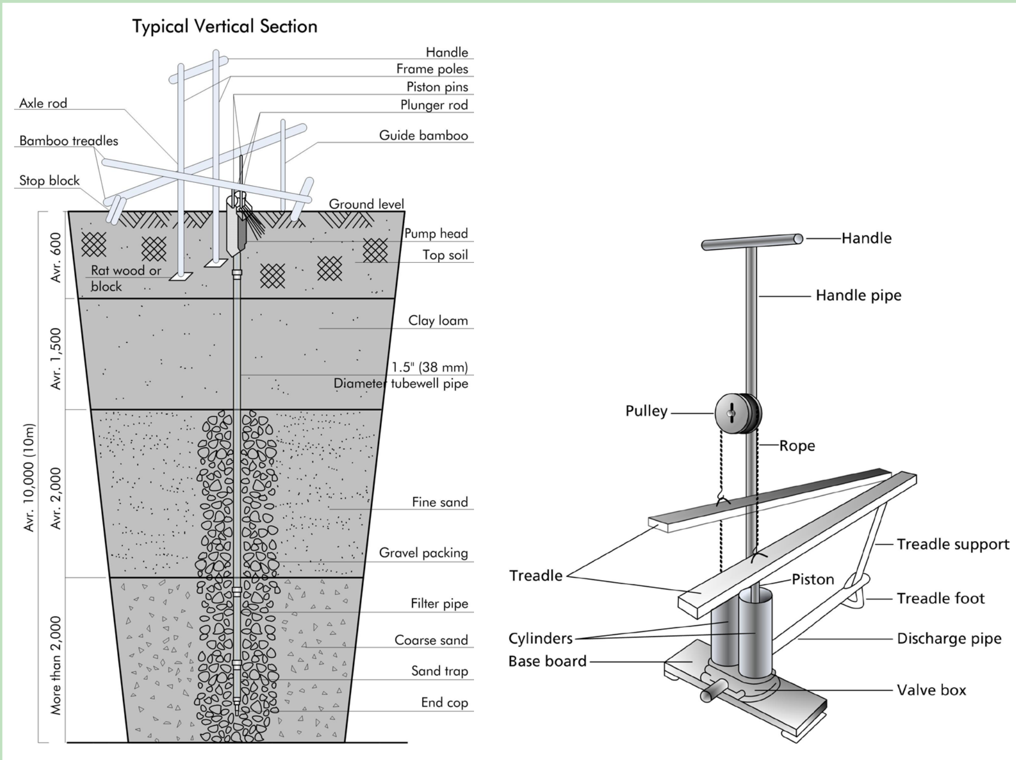
Human environment

Crop land per household (ha)

- □ <0.5
- ■ 0.5–1
- □ 1–2
- □ 2–5
- □ 5–15
- □ 15–50
- □ 50–100
- □ 100–500
- □ 500–1000
- □ 1000–10000
- □ >10000

Land user: individual/household
Population density: more than 500 per km²
Annual population growth: 1–2%
Land ownership: individually, titled
Land/water use rights: individual communally organized
Relative level of wealth: average; more than 50% are relatively well off
Importance of off-farm income: 10–50% of their total income is from off-farm activities

Access to service and infrastructure: low to moderate
Market orientation: mixed subsistence and commercial
Mechanization: animal traction and manual
Livestock grazing on cropland: yes, medium
Livestock density: medium
Purpose of forest / woodland use: not applicable
Types of other land: not applicable



Technical drawing
Components of a treadle pump
(Purusottam Gupta, AK Thaku)

Implementation activities, inputs and costs

Establishment activities

- The site first needs to be evaluated in order to verify whether sufficient groundwater is available.
- The pump should be installed by a trained technician.

Establishment inputs and costs per unit

Inputs	Cost (USD)	% met by land user
Labour (3 person days)	16	100%
Materials		
– Bamboo poles, high density polyethylene (HDP) pipe, galvanized iron (GI) pipe and nipple, HDP pipe filter, pump head, thread tape, solvent and cement	43	100%
TOTAL	**59**	**100%**

Maintenance/recurrent activities

The pump needs to be maintained on a regular basis and, if possible, an extra set of spare parts should be kept on hand. A trained technician should be consulted for major repairs.

Routine maintenance activities are:

- Repairing or replacing the treadle frame

Maintenance/recurrent inputs and costs per unit per year

Inputs	Cost (USD)	% met by land user
Labour (2 person days)	8	100%
Materials		
- Washer, check valve, and bamboo treadle frame	5	100%
TOTAL	**13**	**100%**

Remarks:

- This is an average cost estimate, the actual cost will be a function of the soil type, how far the water table is below the surface, and the type and quality of the materials used (metallic vs. non-metallic, timber vs. bamboo) and the cost of labour.
- All costs and amounts are rough estimates by the technicians and authors. Exchange rate USD 1 = NPR 72 in May 2011.

Assessment

Impacts of the technology

Production and socioeconomic benefits

- +++ Can increase crop yields and farm income by more than 50%
- +++ Can increase the availability of irrigation water by more than 50%
- +++ Can increase the production area by more than 50%
- ++ Decreases workload and labour constraints by 20–50%

Production and socioeconomic disadvantages

none

Socio-cultural benefits

- +++ Improved cultural and recreational opportunities
- +++ Less disputes over water rights and water sharing
- +++ Socially and economically disadvantaged groups benefit significantly and enjoy improved food security

Socio-cultural disadvantages

none

Ecological benefits

- +++ Increased water quantity
- +++ Reduced surface runoff
- ++ Increased soil moisture
- ++ Increased crop diversification
- ++ Farming can continue through periods of drought

Ecological disadvantages

- −− Can reduce the natural water table if water is continuously drawn
- −− The land close to the pump area remains wet and swampy

Off-site benefit

none

Off-site disadvantages

none

Contribution to human wellbeing/livelihood

- +++ Increased farm income helps to improve the lives and livelihoods of smallholder farmers, and of other socially and economically disadvantaged groups.

Benefits/costs according to the land user

Benefits compared with costs	short-term	long-term
Establishment	neutral/ balanced	positive
Maintenance/recurrent	neutral/ balanced	positive

Acceptance/adoption:
Good. Land users are quick to adopt this technology voluntarily even without any external support.

Concluding statements

Strengths and ➔how to sustain/improve	**Weaknesses** and ➔how to overcome
It meets the need for a low-cost irrigation measure and is accessible to farmers ➔ Sustained effort by the government to disseminate information, assist INGOs and local people to get started.	Requires manpower. It irrigates only a limited area. ➔ Continue research and development to make it even simpler to use, possibly even by those who are not so physically fit.
Can be manually operated and does not require any sophisticated or skilled manpower ➔ Make it even easier, simpler, and cheaper to buy and maintain by introducing improved methods and techniques.	Requires continuous inspection and maintenance and a supply of spare parts (washer, check valve, bamboo poles) ➔ Continue research and development to make it even more robust without the need for vigilant maintenance.
Does not require electricity or any other external form of energy so it is easy to implement even in remote places ➔ Continue efforts at research and development to make the pumps even more effective.	Over time, the pumps pump less water, there is frothing, and sand is also lifted ➔ The joints and sockets need tightening. The right place should be selected for boring and, after installation; the area needs to be packed with gravel.
It is an affordable technology for growing vegetables. Purchase and installation are within the means of most farmers and it is easy to maintain. Technical know-how for installation is available locally. ➔ Continue research and development to make pumps even more effective.	At times the pump has trouble lifting water, it is not working properly ➔ Check the treadle frame installation. Check that the size of the washer is appropriate.

Key reference(s): IDE-Nepal (no date) *Technical guideline for treadle pump installation and maintenance.* Kathmandu, Nepal: IDE-Nepal
Contact person(s): Komal Pradhan, IDE-Nepal, Bakhundole, Lalitpur, Nepal; Email: kpradhan@idenepal.org, Tel: +977 1 15520943 (O
ICIMOD © 2013 IDE–Nepal and ICIMOD; published by ICIMOD

Left: Land preparation for riverbed farming in Kailali District (Juerg Merz)
Right: : Bitter gourd produced on riverbed land in Kanchanpur District (Juerg Merz)

Riverbed farming

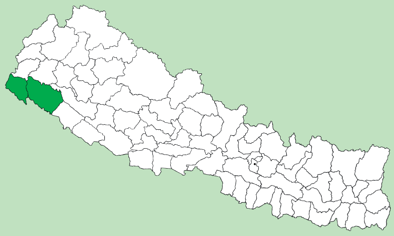
Nepal: बगर खेति

Riverbed farming can be used to increase household income and to improve the food security of landless and land-poor households in the Terai area of Nepal.

It is estimated that about 8,000 hectares of riverbed land would be suitable for agricultural cultivation in the Kailali and Kanchanpur Districts in the Western Terai areas of Nepal. After the river water recedes in the post-monsoon season, vegetables are planted in ditches dug into the seasonal sand banks; the crops are harvested before the onset of the next monsoon. In 2006, Elam Plus of HELVETAS Swiss Inter-cooperation Nepal, assessed local practices of riverbed farming and piloted an improved approach with 670 farmers, mostly from the indigenous Tharu community. During the first year they cultivated 43 hectares. Since the initial results indicated that riverbed farming could increase the target population's income significantly, the programme was expanded from the initial two districts (Kailali and Kanchanpur) to two new districts (Banke, and Bardiya). The number of households was increased to 2000 in 2008 and 3165 in 2012 after the initiative won a Global Development Market Place award from the World Bank.

Requirements for riverbed farming:

- On average, the water table should not be lower than 1 m; when the water table is lower than this, too much labour is required.
- Plots are allocated perpendicular to the river flow in order to give each farmer access to a variety of land types (and moisture levels) suitable for different crops.
- Ditches are up to 1 m deep and 1 m wide. The length depends on how much land is available.
- A row-to-row spacing of 2–3 m (between the ditches) and plant-to-plant spacing of 0.5–1 m is required depending on the crop.
- The ditches are dug in an east-west orientation to maximize the amount of sunshine they receive and to minimise the collection of sand carried by the prevailing winds.
- Riverbed farmers can build shelters close to their plots so that they can be close at hand to fend off thieves and wild animals.



WOCAT database reference: QT NEP 34
Location: Kanchanpur and Kailali Districts, Nepal
Technology area: 4 km^2
Conservation measure(s): Agronomic
Land Use: Originally fallow land now used for one season crop plantation
Stage of intervention: Rehabilitation for income generation
Origin: Ganges plains of India
Climate: Humid/subtropical
Related approach: Land distribution and allocation for riverbed farming (QA NEP 34)
Compiled by: Hari Gurung, Elam Plus, Helvetas Swiss Intercooperation
Date: April 2011, updated March 2013

The technology was documented using the WOCAT (www.wocat.org) tool.

ICIMOD HELVETAS Swiss Intercooperation NEPAL WOCAT

Classification

Land use problems

Rivers in the Terai region change their course frequently and when they do, the adjacent lands are flooded. The riverbeds are flooded annually, while the riverbanks are only flooded during extreme events. The annually flooded riverbeds are seasonally dry (from September to May) and are a generally unused land resource. Landless and land- poor farmers can use this land to cultivate seasonal vegetables that are adapted to the environmental conditions prevalent on riverbeds.

Land use

Annual crops; different types of vegetables (water melon, pumpkin, gourds, cucumber)

Climate

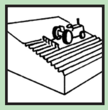
Humid/ subtropical

Degradation

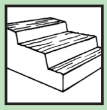
Water erosion

Water erosion

Conservation measures



Agronomic: introduction of a new crop



Structural measure

Stage of intervention

- ☐ Prevention
- ■ Mitigation/reduction
- ☐ Rehabilitation

Origin

- ☐ Land users' initiative
- ☐ Experiment/research
- ■ Externally introduced
- ☐ Other (specify)

Level of technical knowledge

- ☐ Low
- ■ Medium: land user
- ☐ High

Main causes of land degradation: Flood

Technical function/impact

Main:
- Supports income generation
- Increases and maintains water stored in the soil

Secondary:
- Improves of ground cover
- Stabilizes the soil
- Increases organic matter in the soil

Environment

Natural environment

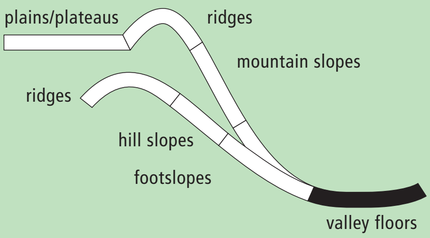
Average annual rainfall (mm)

- ☐ >4000
- ☐ 3000–4000
- ☐ 2000–3000
- ■ 1500–2000
- ☐ 1000–1500
- ☐ 750–1000
- ☐ 500–750
- ☐ 250–500
- ☐ <250

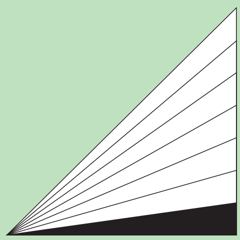
Altitude (masl)

- ☐ >4000
- ☐ 3000–4000
- ☐ 2500–3000
- ☐ 2000–2500
- ☐ 1500–2000
- ☐ 1000–1500
- ☐ 500–1000
- ■ 100–500
- ☐ <100

Landform



Slope (%)



Soil depth (cm)

- ☐ 0–20
- ☐ 20–50
- ☐ 50–80
- ☐ 80–120
- ■ >20

Growing season(s): November to May
Soil texture: sandy
Soil fertility: medium
Topsoil organic matter: low
Soil drainage/infiltration: well-drained

Soil water storage capacity: low
Groundwater table: 30–50 cm depth
Availability of surface water: low
Water quality: good
Biodiversity: low

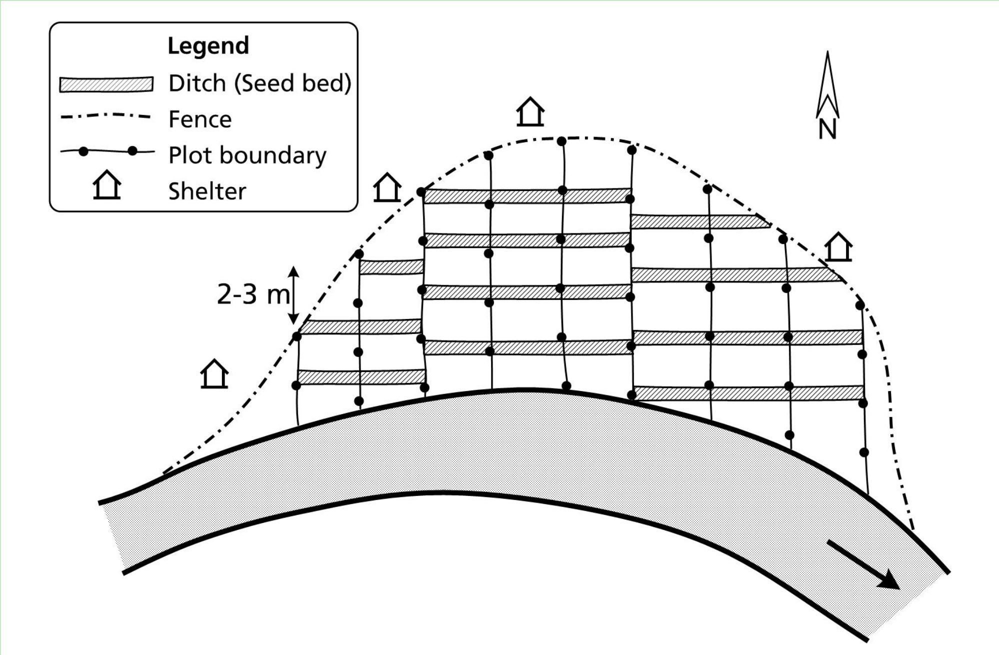
Tolerant of climatic extremes: riverbed farming is not affected by either low rainfall or high temperatures since the plants for cultivation are chosen based on their ability to survive difficult environments
Sensitive to climatic extremes: too frequent high flooding threatens riverbed farming
If sensitive, what modifications were made/are possible: planting either earlier or later depending on the crop; planting farther away from the river, expansion to the river banks; flood insurance

Human environment

Crop land per household (ha)

- ■ <0.5
- ☐ 0.5–1
- ☐ 1–2
- ☐ 2–5
- ☐ 5–15
- ☐ 15–50
- ☐ 50–100
- ☐ 100–500
- ☐ 500–1000
- ☐ 1000–10000
- ☐ >10000

Land user: landless, land-poor
Population density: high
Annual population growth: high
Importance of off-farm income: high
Access to service and infrastructure: low
Market orientation: semi-commercial to commercial



Technical drawing
Plots for riverbed farming are allocated perpendicular to the river flow and the ditches are dug in an east-west orientation. (J Merz, AK Thaku)

Implementation activities, inputs and costs

Establishment activities

- Dig ditches in an east-west direction about 2 to 3 m apart. The ditches can be up to 1 m deep and 1 m wide; the length will depend on the shape of the land.
- Apply fertilizer: farmyard manure/compost about 12 tonnes; urea about 100 kg; di-ammonium phosphate (DAP) about 120 kg; and potash about 30 kg per ha.
- Plant seeds/seedlings using the appropriate row-to-row (RXR) and plant-to-plant (PXP) distance for at least one crop. A row-to-row distance of 3 m is required for bottle gourd, pumpkin, and water melon and 2 m for bitter gourd and cucumber; a plant-to-plant distance of 0.5 m is needed for cucumber and bitter gourd and 1 m for water melon, bottle gourd, and pumpkin.

Establishment inputs and costs per ha

Inputs	Cost (USD)	% met by land user
Labour to prepare the plots, for irrigation, and to collect mulching materials (165 person days)	232	100%
Equipment - Sprayers, watering cans, spades	42	0%
Materials - Polythene bags, sheets, mulching materials	21	0%
Agricultural - Seeds, chemical fertilizer, farmyard manure, compost, bio-pesticides, micro nutrients	267	0%
TOTAL	**562**	**41%**

Maintenance/recurrent activities

- Water new plots every 2 to 3 days; as the seedlings mature, water weekly or as needed depending on the weather and the soil conditions.
- Replace seedlings that have died and replant seeds in places where they have not germinated
- Top dress with nitrogen, phosphorous, potassium
- Mulch with straw and grass
- Weed and protect plants as needed
- Protect the riverbed areas throughout the growing season as they are prone to attacks by thieves and wild animals, mainly jackals and monkeys. However, note that the reported losses to date have been very minimal.

Maintenance/recurrent inputs and costs per ha per 7 months

Inputs	Cost (USD)	% met by land user
Labour (30 person days)	42	100%
Equipment - Watering cans, sprayers, spades	28	25%
Materials - Polythene bags, sheet bags, mulching materials	11	50%
Agricultural - Seeds, organic fertilizer required for re-planting, bio-pesticides for insect and pest control	84	25%
TOTAL	**165**	**45%**

Remarks:

- All costs and amounts are rough estimates by the technicians and authors. Exchange rate USD 1 = NPR 71 in April 2011.

Assessment

Impacts of the technology

Production and socioeconomic benefits

- + + + Increased income; a household can earn approximately USD 300 on average from 0.13 ha of land
- + + + Riverbed crops can be exchanged for food grain; on average, this can provide an additional four months of food security
- + + Additional income can be used to cover school fees and health services
- \+ Provides vegetables for riverbed farming households

Production and socioeconomic disadvantages

- − Dependant on external agricultural inputs
- − − Crops can be lost during floods, cold spells, and hailstorms

Socio-cultural benefits

- \+ Reduces the need for income usually met by migration and by off-farm daily wage labour
- + + Increases the social status of local resource persons

Socio-cultural disadvantages

- − Conflicts can arise when the land is being allocated
- − − Border conflicts can arise between different groups

Ecological benefits

- \+ The green cover is increased by farming these marginal riverbed lands. During the spring season this minimizes soil loss due to wind erosion and has ecological benefits. Some encroachment takes place when ditches or pits are dug at frequent intervals since these are covered with green matter during the growing season.

Ecological disadvantages

- − The use of pesticides in the case of massive pest invasions may affect the water quality
- − − Excessive use of fertilizers may affect water quality

Off-site benefit

- \+ Local availability of fresh vegetables

Off-site disadvantages

- − Glut of riverbed farming produce during the season

Contribution to human wellbeing/livelihood

- + + + Provides alternative means of income as well as food security for landless and land-poor households

Benefits/costs according to the land user

Benefit to land users is high; they can obtain at least five times the return on their investment. (Note: Initial results from 2012 indicated that riverbed farming can increase meaningful income of landless and land poor: 3165 households made (on average) an income of USD 240 from 0.13 hectare of land by investing USD 45).

Benefits compared with costs	short-term	long-term
Establishment	positive	positive
Maintenance/recurrent	positive	positive

Acceptance/adoption:

The majority of riverbed farmers among the first few groups to learn the technique continued riverbed farming after support for the project ended. In the third year, 55 of the original 61 groups were still farming on the riverbed even though they did not receive any agricultural inputs with the exception of support from the local resource persons. The local resource persons have organized themselves into an independent organisation that now provides technical support through the Micro Enterprise Development Fund and through individual channels. Now that Nepali farmers have started to farm the riverbeds in the Kailali and Kanchanpur Districts, the number of Indian farmers who previously farmed these riverbeds has drastically diminished.

Concluding statements

Strengths and ➔how to sustain/improve	**Weaknesses** and ➔how to overcome
Riverbed farming provides a new source of income for landless and land-poor households ➔ Continue to provide technical support through local resource persons. These persons can be supported through district-based instruments such as the Micro Enterprise Development Fund. ➔ Local governing bodies such as the district development committees, municipalities, and village development committees, can support riverbed farming with their own funds; can support farmers with the land leasing process, can help to identify primary stakeholders, and can also help by promoting policies that are favourable towards riverbed farming.	Competition from riverbed products originating in India and a glut during the season ➔ Riverbed farmer groups need to improve their understanding of the value chain and their access to markets.
Riverbed farming has a very high cost-benefit ratio and a very low investment requirement. ➔ Continue to promote this technology among primary stakeholders.	Mineral fertilizer and biopesticides are now used to ensure a good harvest ➔ Promote sustainable soil management practices including the use of farmyard manure, urine collection, and bio-pesticides
All services including the supply of quality seeds, tools, and materials are now processed through the local agrovets and agricultural extension is available through local resource persons. These are locally available and of high quality. ➔ Agrovets, local resource persons, and their associations may need further capacity building through different channels such as the Micro Enterprise Development Fund, and/or the District Agricultural Development Office.	Land ownership of riverbed land is often contested ➔ Long term leasehold agreements need to be negotiated with land owners.

Key reference(s): HELVETAS (no date) *Riverbed farming manual and local resource person training modules.* Kathmandu, Nepal: HELVETAS Swiss Intercooperation Nepal

Contact person(s): Programme Coordination Office HELVETAS Swiss Intercooperation Nepal, GPO Box 688, Kathmandu/Nepal, po@helvetasnepal.org.np, Tel: +977 1 5524925; Dr Juerg Merz, juerg.merz@helvetas.org.np Tel: +977 9851044421 (M); or Hari Gurung at hari.gurung@helvetas.org.np; Tel: 9741056444 (M)

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Right: An eroded riverbank in Dang District (Udhaw B Ghimire)
Left: The same riverbank area as on the right after a check dam (bamboo poles and brushwood) and spur (gabion boxes filled with river stones) were constructed using local measures. (Udhaw B Ghimire)

Riverbank protection

Nepal: नदी किनार संरक्षण

Local materials and knowledge can be used to construct low-cost structural measures that help to prevent the erosion of riverbanks and the loss of agricultural and residential land.

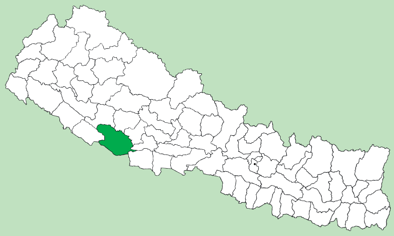
Riverbank cutting occurs naturally along the rivers that run along the foothills of the Chure (Siwalik) range in Nepal when the stream collides with the river bank or the bank is eroded by water coming from agricultural land above the affected area. When riverbank cutting occurs, it leaves behind an eroded area shaped like a small cliff. This erosion takes place naturally and is difficult to stop because the site is devoid of natural vegetation. It is important to undertake conservation measures because when the riverbank is eroded it damages agricultural land and decreases soil fertility. When the productivity of the land is decreased it affects the lives and livelihoods of nearby communities most of whom are subsistence farmers.

Communities have developed local measures to help protect the riverbanks and to prevent further erosion and cutting. This technology uses both structural and vegetative measures to help control the erosion and protect both agricultural land and settlement areas from flooding. Check dams are placed at intervals to divert water, additional support is provided by spurs. Bamboo rhizomes are planted between them and Napier grass (*Pennisetum purpureum*) is planted at the back of the structures so that as the plants grow their roots help to anchor the structure. The washed out areas can be used to generate some income by planting them with greenery and fruit trees. The site needs to be monitored annually and where necessary the structures either need to be repaired or supplemented by building additional structures.

This technology is a blend of local skills and expertise with some external technical input. The key features of the technology are as follow:

- It uses locally available construction materials, tools, equipment, and vegetation.
- It is easy to replicate.
- It is affordable for local people.
- It is environmentally friendly.

A demonstration plot was established by the District Soil Conservation Office (DSCO) in Dang, but the technology needs to be replicated in other areas with action research and experience.



WOCAT database reference: QT NEP 28
Location: Gobardiha-9, Madhabpur, Dang District, Nepal
Technology area: <0.1 km^2
Conservation measure(s): Structural and vegetative
Land Use: Cropland
Stage of intervention: Prevention, mitigation, and reduction of land degradation
Origin: Externally through the District Soil Conservation Office (DSCO), Tulsipur, Dang
Climate: Subhumid/tropical
Related approach: Not described
Compiled by: Uddhaw B Ghimire, District Soil Conservation Office (DSCO), Tulsipur, Dang
Date: December 2010, updated March 2013

The technology was documented using the WOCAT (www.wocat.org) tool.

ICIMOD

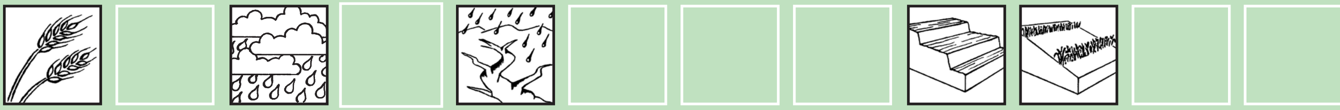
WOCAT

Classification

Land use problems

The land is degraded by riverbed cutting and nearby villages are threatened by flooding. The amount of land available for agriculture decreases annually giving rise to a food security problem. Entire villages may have to move to avoid being flooded.

Land use | **Climate** | **Degradation** | **Conservation measures**



Annual cropping, mixed (rainfed – irrigated)

Subhumid/ tropical

Water erosion: riverbank erosion

Structural measure

Vegetative measure

Stage of intervention

- ■ Prevention
- ■ Mitigation/reduction
- □ Rehabilitation

Origin

- □ Land users' initiative
- □ Experiment/research
- ■ Externally introduced: DSCO, Dang
- □ Other (specify)

Level of technical knowledge

- ■ Low: DSCO, Dang staff
- ■ Medium: land user
- □ High

Main causes of land degradation: River flooding

Technical function/impact

Main:
- Controls concentrated runoff (impede/retard)
- Controls dispersed runoff (impede/retard)

Secondary:
- Improves ground cover
- Stabilizes soil with vegetation so it is more resistant to landslides

Environment

Natural environment

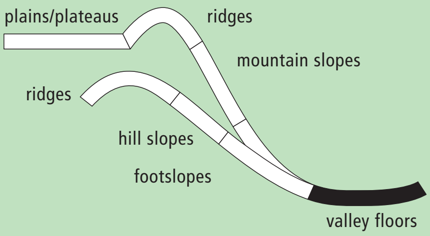
Average annual rainfall (mm)

- □ >4000
- □ 3000–4000
- □ 2000–3000
- ■ 1500–2000
- □ 1000–1500
- □ 750–1000
- □ 500–750
- □ 250–500
- □ <250

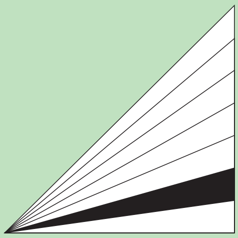
Altitude (masl)

- □ >4000
- □ 3000–4000
- □ 2500–3000
- □ 2000–2500
- □ 1500–2000
- □ 1000–1500
- □ 500–1000
- ■ 100–500
- □ <100

Landform



Slope (%)



Soil depth (cm)

- □ 0–20
- ■ 20–50
- □ 50–80
- □ 80–120
- □ >20

Growing season(s): two
Soil texture: coarse/light sandy
Soil fertility: very low
Topsoil organic matter: low (<1%)
Soil drainage/infiltration: good

Soil water storage capacity: very low
Groundwater table: 5–50 m
Availability of surface water: poor/none
Water quality: good for agricultural use only
Biodiversity: low

Tolerant of climatic extremes: increases in temperature and seasonal rainfall
Sensitive to climatic extremes: floods
If sensitive, what modifications were made/are possible: Previously, the problem was tackled using traditional techniques alone but the results were not wholly satisfactory. After modifying (as discussed below) the structures are more robust and can withstand greater floods.

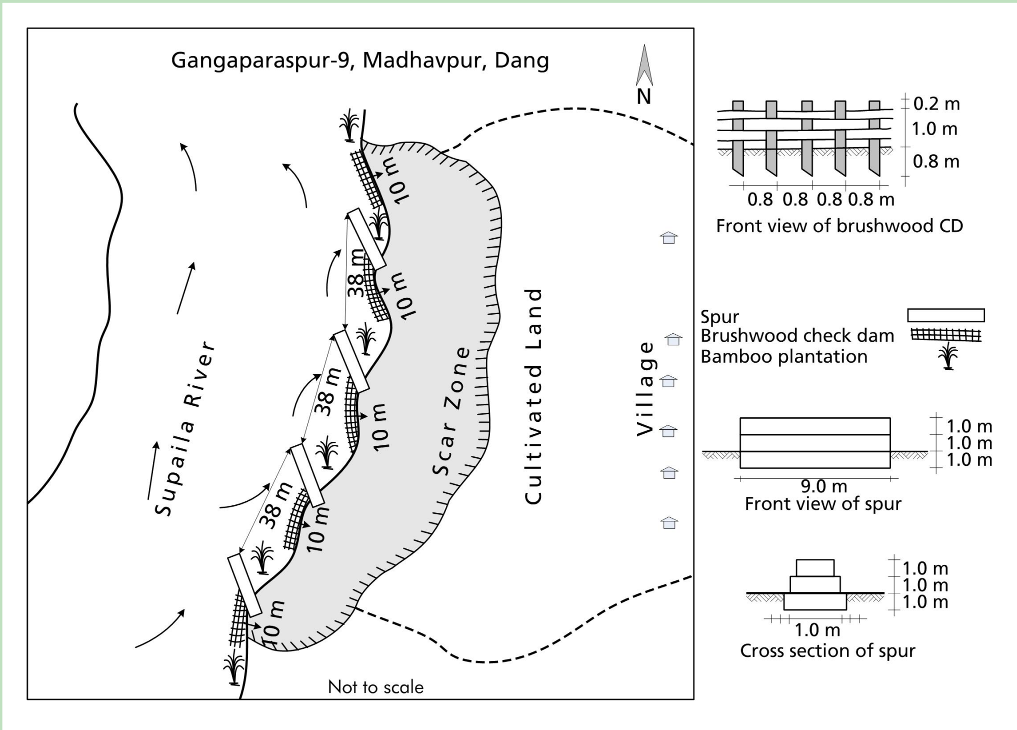
Human environment

Crop land per household (ha)

- ■ <0.5
- □ 0.5–1
- □ 1–2
- □ 2–5
- □ 5–15
- □ 15–50
- □ 50–100
- □ 100–500
- □ 500–1000
- □ 1000–10000
- □ >10000

Land user: groups, community
Population density: 100–200 per km^2
Annual population growth: 2.7% per year
Land ownership: individual, titled
Land/water use rights: land is individually owned, water rights are communal (organized)
Relative level of wealth: poor
Importance of off-farm income: >50% of all income
Access to service and infrastructure: low to high

Market orientation: subsistence
Mechanization: animal traction and manual labour
Livestock grazing on cropland: yes
Livestock density: medium
Purpose of forest / woodland use: fuelwood, grazing (on forest land)



Technical drawing
A low cost riverbank protection scheme that can be implemented using mostly local materials.
(Bhojdeo Mandal, AK Thaku)

Implementation activities, inputs and costs

Establishment activities

Vegetative

- Pitting
- Bamboo planting
- Napier grass planting

Structural

- Check dam construction
- Spur construction

Establishment inputs and costs per ha

Inputs	Cost (USD)	% met by land user
Labour (total skilled and non-skilled, 130 person days)	892	51%
Equipment		
- tool	21	51%
Materials		
- stones (m^3)	1,281	
- bamboo poles	274	
- wire for gabion boxes	1,644	51%
others		
- Napier grass, bamboo seedlings	14	0%
TOTAL	**4,126**	**51%**

Maintenance/recurrent activities

Maintenance costs cover only replacement and maintenance to be done by the local community for a few years until the vegetative structures are well established at the site.

Vegetative
Check to see that the Napier grass seedlings have taken root; add additional plants as needed.

Structural
Verify the integrity of the spurs and check dams; fortify or repair as needed.

Maintenance/recurrent inputs and costs per ha per year

Inputs	Cost (USD)	% met by land user
Labour (9 person days)	52	100%
Materials		
- bamboo poles	123	100%
others		
- Napier grass and others	7	100%
TOTAL	**182**	**100%**

Remarks:

- The costs for the gabion boxes, the transportation costs, and some skilled labour, were borne by the DSCO, Dang; whereas, the costs for the tools, local materials, and all of the unskilled labour were borne by the local community.
- All costs and amounts are rough estimates by the technicians and authors. Exchange rate USD 1 = NPR 72 in December 2010.

Assessment

Impacts of the technology

Production and socioeconomic benefits

- +++ Reduced risk of production failure
- ++ Increased farm income
- ++ Decreased workload
- + Diversification of income sources

Production and socioeconomic disadvantages

none

Socio-cultural benefits

- +++ Strengthening of community institutions
- +++ Improved situation of socially and economically disadvantaged groups
- ++ Improved food security and self-sufficiency; reduced dependence on external support

Socio-cultural disadvantages

none

Ecological benefits

- +++ Improved resilience to hazards and adverse events such as droughts, floods, and storms
- +++ Reduced soil loss

Ecological disadvantages

none

Off-site benefit

- ++ Reduced downstream flooding
- ++ Public and private infrastructure, even at some distance from the site, have a reduced risk of flooding

Off-site disadvantages

none

Contribution to human wellbeing/livelihood

- + Agricultural land is conserved and production is increased

Benefits/costs according to the land user

Benefits compared with costs	short-term	long-term
Establishment	very positive	very positive
Maintenance/recurrent	positive	positive

Acceptance/adoption:
A community of 47 households has agreed to use this technology to help prevent soil erosion caused by flooding. The community had started to implement local measures to minimize riverbank cutting but the efforts were not successful. The systematic introduction of well-planned gabion spurs and bamboo check dams constructed using only locally available materials, has been successful. The community is convinced that this technology is beneficial and they will continue to propagate it themselves as needed.

Concluding statements

Strengths and ➔how to sustain/improve	**Weaknesses** and ➔how to overcome
The technology is low cost and can be implemented by the local community with the assistance of some technical support from the DSCO, Dang.➔ The DSCO, Dang, needs to continue to support the community in its efforts by technical backstopping, regular follow-up, and continued scaling up of the technology.	Vegetative structures may not always take root as intended; the initial cost for the gabion cages can be high. ➔ Try to implement the technology using vegetative measures.
The technology predominantly uses locally available materials. ➔ Replication of this technology should be encouraged by the community as well as by the DSCO, Dang.	Despite the fact that the technology is known to be effective, it is not being widely implemented. ➔ Communities need greater awareness; intensive extension is needed in order for the technology to have wide-spread acceptance.
In the long run, vegetative structures help to propagate greenery and in so doing, they promote climate change adaptation and mitigation. ➔ Communities should be made aware of the hazards of climate change and of what mitigation measures can be employed.	
Traditional measures used to help protect against flooding were very labour intensive and difficult to implement. This new method is low cost, easy to adopt, and sustainable. ➔ Additional training with local communities can help to spread the expertise.	

Key reference(s): Annual Report (2065/66), District Forest Office, Dang; Soil Conservation and Watershed Management Measures and Low Cost Techniques; Environment Statistics of Nepal 2008(www.cbs.gov.np); Bhu Samrakshan Tathaa Jalaadhaar Byabasthaapan Upaaya Tathaa Kam Kharchilo Prabidhi- all are available at the DSCO, Dang and DCSWM, Kathmandu.
Contact person(s): Programme Coordination Office HELVETAS Swiss Intercooperation Nepal, GPO Box 688, Kathmandu/Nepal, po@helvetasnepal.org.np, Tel: +977 1 5524925; Uddhaw B Ghimire, District Soil Conservation Office, Dang; Email: ghimire_uddhaw@yahoo.com; Tel: +977 82 520061 (O), 9847113107 (M)

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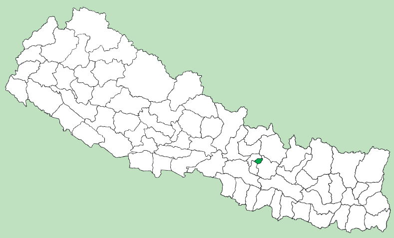
Left: Newly planted Salix cuttings along the stream bank are protected by biofencing. (Indira Mulepati)
Right: Well-established Salix rows along a stream bank. (Indira Mulepati)

Using Salix plants to protect stream banks

Nepal: बैंस रोपी खोला किनार संरक्षण

Stream banks can be protected by planting them with Salix (*Salix babylonica*); this is a traditional practice that has been used for streams that flow through agricultural lands.

The erosion of stream banks is a natural geomorphic process, but when the streams flow through agricultural land there is a danger that they can overrun their banks and damage crops or erode land used for cultivation. The degree of erosion can be reduced by using structural measures such as lining the banks with concrete or large boulders or by planting trees along the edges. The Salix plant (*Salix babylonica*) has been found to be particularly useful for preventing erosion because its roots extend deep into the soil and help to anchor the bank. Following age-old tradition, land users in Bhaktapur district have planted Salix along the Bramayaeni khola (stream). It is a low-cost technology that is simple to implement.
Salix does best in moist soils, such as those found along irrigation channels and along the banks of rivers and streams. Salix saplings are most commonly planted in single rows but sometimes in double rows. After the saplings are planted, the entire area is fenced off using a biofence to protect them from being eaten or trampled by wild animals. Land users keep an eye on the Salix and prune or thin them as needed, for example when it is shading crops, or when they need firewood or can sell the branches.



WOCAT database reference: QT NEP 29
Location: Bhaktapur Municipality-2, Nantukucha, Bhaktapur District, Nepal
Technology area: 0.026 km^2
Conservation measure(s): Vegetative
Land Use: Annual cropping, irrigated land
Stage of intervention: Prevention of land degradation
Origin: Traditional
Climate: Sub humid/temperate
Related approach: Not described
Other related technology: Landslip and stream bank stabilization (QT NEP 11)
Compiled by: Indira Mulepati, Department of Soil Conservation and Watershed Management (DSCWM), Kathmandu
Date: April 2011, updated March 2013

The technology was documented using the WOCAT (www.wocat.org) tool.

Classification

Land use problems

When streams overflow their banks, agricultural land can be flooded and eroded.

Land use

Annual cropping (mixed rainfed and irrigated)

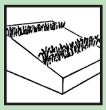
Climate

Subhumid/ temperate

Degradation

Water erosion: streambank erosion

Conservation measures



Vegetative measure

Stage of intervention

- ■ Prevention
- □ Mitigation/reduction
- □ Rehabilitation

Origin

- ■ Land users' initiative traditional
- □ Experiment/research
- □ Externally introduced
- □ Other (specify)

Level of technical knowledge

- □ Low
- ■ Medium: land user
- □ High

Main causes of land degradation: stream bank cutting during flood events

Technical function/impact

Main:
- The Salix roots reinforce the soil and support it by buttressing and arching.
- Salix armours the slope against surface erosion.

Secondary:
- Floodwater is safely channelled downstream.

Environment

Natural environment

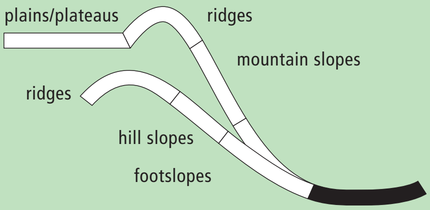
Average annual rainfall (mm)

- □ >4000
- □ 3000–4000
- □ 2000–3000
- □ 1500–2000
- ■ 1000–1500
- □ 750–1000
- □ 500–750
- □ 250–500
- □ <250

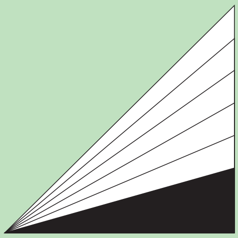
Altitude (masl)

- □ >4000
- □ 3000–4000
- □ 2500–3000
- □ 2000–2500
- □ 1500–2000
- ■ 1000–1500
- □ 500–1000
- □ 100–500
- □ <100

Landform



Slope (%)



Soil depth (cm)

- □ 0–20
- □ 20–50
- □ 50–80
- □ 80–120
- ■ >20

Growing season(s): two
Soil texture: loam
Soil fertility: high
Topsoil organic matter: high
Soil drainage/infiltration: good

Soil water storage capacity: medium
Groundwater table: <50 m
Availability of surface water: good
Water quality: good for agricultural use only
Biodiversity: medium

Tolerant of climatic extremes: increases in temperature and seasonal rainfall, floods
Sensitive to climatic extremes: dry spells and droughts
If sensitive, what modifications were made/are possible: Plant Salix lower down the stream banks so that plants can access seepage water from the stream.

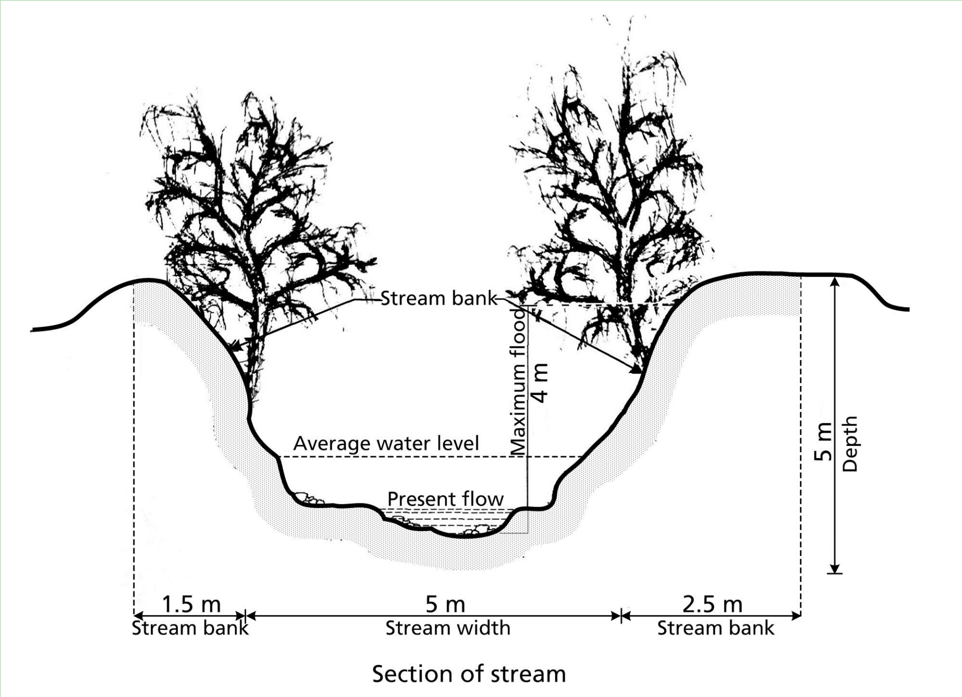
Human environment

Crop land per household (ha)

- ■ <0.5
- □ 0.5–1
- □ 1–2
- □ 2–5
- □ 5–15
- □ 15–50
- □ 50–100
- □ 100–500
- □ 500–1000
- □ 1000–10000
- □ >10000

Land user: individual and households
Population density: 1,895 per km^2
Annual population growth: 2.7%
Land ownership: individual, titled
Land/water use rights: land rights are individual, but water rights are communal (i.e. organized)
Relative level of wealth: well off
Importance of off-farm income: >50% of all households
Access to service and infrastructure: high

Market orientation: mixed (subsistence and commercial)
Mechanization: manual labour
Livestock grazing on cropland: not applicable
Livestock density: not applicable
Purpose of forest/woodland use: not applicable
Types of other land: not applicable



Technical drawing
Schematic diagram of a low cost riverbank protection scheme that can be implemented using mostly local materials.
(Bhojdeo Mandal, AK Thaku)

Implementation activities, inputs and costs

Establishment activities

Establishment activities are carried out in January and February

1. The planting site is cleared.
2. Cuttings are taken from 3–5 year-old trees: average length: 2–2.5 m; average diameter: 5–7 mm.
3. Planting pits approximately 30 cm in diameter and 90 cm deep are dug into the stream bank approximately 1–2 m apart.
4. The Salix cuttings are planted so that one-third of their length is below the surface of the soil.
5. After planting, the soil is compacted around the base of the cuttings.
6. The cuttings are watered soon after planning and again at least three times per month

In June and July, six months after planting, the cuttings that have survived and taken hold should show new shoots.

Establishment inputs and costs per ha

Inputs	Cost (USD)	% met by land user
Labour for pitting, branch cutting, transport, and planting (150 person days)	584	100%
Materials - Salix cuttings	186	100%
TOTAL	**770**	**100%**

Maintenance/recurrent activities

The established Salix is thinned or pruned if it is found to be shading crops. New cuttings are planted in areas where cuttings have failed to take root.

Maintenance/recurrent inputs and costs per ha per year

Inputs	Cost (USD)	% met by land user
Labour for replanting and pruning (10 person days)	39	100%
Agricultural - Salix cuttings	35	100%
TOTAL	**74**	**100%**

Remarks:

- The labour cost is very high in Bhaktapur District; when compared to other parts of the country it is probably the highest.
- All costs and amounts are rough estimates by the technicians and authors. Exchange rate USD 1 = NPR 71 in April 2011

Assessment

Impacts of the technology

Production and socioeconomic benefits	Production and socioeconomic disadvantages
+ + + Reduced risk of production failure	none
+ + New land can be brought under cultivation/use	
+ + Increased fodder production	
+ Diversification of income sources	

Socio-cultural benefits	Socio-cultural disadvantages
+ + + Improved understanding of conservation measures	none
+ + Strengthening community institutions	

Ecological benefits	Ecological disadvantages
+ + + Reduced susceptibility to adverse events such as floods	− Salix can shade crops
+ + + Reduced soil loss	
+ + + Increased biomass available	
+ + Improved drainage of excess water	
+ Reduced evaporation	

Off-site benefit	Off-site disadvantages
+ + Reduced probability of flooding that can damage both public and private infrastructure	none
+ Improved water availability downstream because water remains contained in the stream	

Contribution to human wellbeing/livelihood

+ Farm income is increased when more land is available for cultivation and when more fodder and fuelwood are available.

Benefits/costs according to the land user

Benefits compared with costs	short-term	long-term
Establishment	positive	very positive
Maintenance/recurrent	very positive	very positive

Acceptance/adoption:
All of the 148 households studied implement this technology voluntarily without external support.

Concluding statements

Strengths and ➔how to sustain/improve	**Weaknesses** and ➔how to overcome
It is a successful example of sustainable land management that has been very effective in Nepal. ➔ An awareness programme on the importance of stream bank protection would help to validate and reconfirm this age-old practice.	There are no funds to help extend the technology to other areas. ➔ More funding should be made available for stream bank protection either from the District Soil Conservation Office or private organizations.
This low-cost technology is applied using indigenous knowledge. ➔ Scientific and technical input might help to make this technology more effective.	When newly planted Salix cuttings are overrun by khosima, a new invasive species, they gradually die. ➔ Technical backstopping is needed for the removal of unwanted species.

Key reference(s): None

Contact person(s): Indira Mulepati, Department of Soil Conservation and Watershed Management, Babarmahal, Kathmandu, Nepal;
Email: indiramulepati@yahoo.com; imulepati@gmail.com, Tel: +977 1 4220828, 4220857, +977 9841477371 (M)

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Left: A farmer grafting tomato seedlings (Purusottam Gupta)
Right: A farmer in Syngia showing tomato seedlings that have been grafted onto improved root stocks. (Purusottam Gupta)

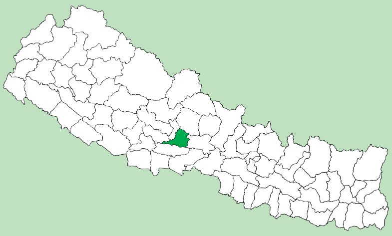
Tomato grafting

Nepal: कलमी प्रबिधिद्वारा गोलभेडा उत्पादन

Cleft grafting can be used to produce plants that are resistant to a number of pests and diseases and are often higher yielding than the original. Tomato seedlings can be easily grafted onto resistant root stock of the wild eggplant (*Solanum sysimbrifolium*) to produce a disease-resistant and commercially viable crop.

Some of Nepal's most lucrative vegetable cash crops, especially solanaceous crops such as tomato and eggplant, are particularly susceptible to attack by the root knot nematode, *Meliodogyne* spp, which costs Nepal's farmers millions of rupees in losses annually. In recent years, farmers found that this pest was becoming prevalent and that they could not control it permanently using either cheap or eco-friendly solutions. Researchers and development officers took up the challenge and found that grafting technology could successfully control not only the root knot nematode but also wilting disease. As a bonus, they also found that grafting can increase the yield potential of the plants and improve the overall productivity of the land.

Loam and silt loam soils with a pH of 6.0–7.0 are the most suitable for this type of cultivation. Grafting technology requires two plants: the scion and the rootstock. The scion is a detached shoot or twig containing buds from the desired woody plant. The rootstock is a plant with an established healthy root system, onto which a cutting or a bud from another plant is grafted. The scion seedlings are grown in raised solarized nursery beds, where care has been taken to see that the soil has been sterilised and all soil pests have been destroyed. Robust rootstock of wild eggplant (*Solanum sysimbrifolium*) is appropriate for tomato propagation. The rootstock seedlings are grown in multi cell trays and transplanted when they are 20–25 cm high and have a few leaves and a pencil thick stalk. Seeds for the rootstock seedlings are sown in March/April and are ready in 6–8 weeks; scion seeds are sown in April/May and are ready for grafting in 3–4 weeks. Both scion and rootstock plants should have achieved similar stalk thicknesses at the time of grafting. Cleft grafting is carried out and the grafted seedlings kept in polypots in a closed polyhouse for 7–10 days. Then the grafted seedlings are carefully transplanted to their permanent location. The grafted plants are watered the day after they are transplanted; the extent of watering depends on how moist the soil is and on local weather conditions. The field is mulched throughout the cropping period using straw and other farm biomass materials.



WOCAT database reference: QT NEP 33
Location: Arukharka -6, Syangja District, Nepal
Technology area: <0.1 km^2
Conservation measure(s): Agronomic
Land Use: Cropland, annual cropping
Stage of intervention: Income generation
Origin: Introduced through projects
Climate: Subhumid/subtropical
Related approach: Using the participatory market chain approach to help smallhold farmers market their produce (QA NEP 33)
Compiled by: Purusottam Gupta, IDE Nepal
Date: May 2011, updated March 2013

The technology was documented using the WOCAT (www.wocat.org) tool.

ICIMOD iDE नेपाल Nepal WOCAT

Classification

Land use problems
Insufficient water for irrigation, the soil is acidic, vegetable crops are attacked by pests and crop production is in decline.

Land use

Annual cropping (rainfed)

Climate

Subhumid/ subtropical

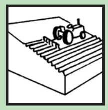
Degradation

Biological degradation: loss of production (pest attack)

Chemical degradation: low soil pH, fertility decline

Water degradation: soil moisture problem

Conservation measures



Agronomic measure

Stage of intervention

- [x] Prevention
- [ ] Mitigation/reduction
- [ ] Rehabilitation

Origin

- [ ] Land users' initiative
- [ ] Experiment/research
- [x] Externally introduced: IDE-Nepal
- [ ] Other (specify)

Level of technical knowledge

- [ ] Low
- [x] Medium: technical staff
- [x] High

Main causes of land degradation: Over use of chemical fertilizers, poor soil management, drought

Technical function/impact

Main:
- Reduces pest attacks
- Improves crop production

Secondary:

Environment

Natural environment

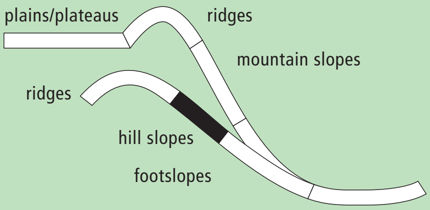
Average annual rainfall (mm)

- [ ] >4000
- [ ] 3000–4000
- [x] 2000–3000
- [ ] 1500–2000
- [ ] 1000–1500
- [ ] 750–1000
- [ ] 500–750
- [ ] 250–500
- [ ] <250

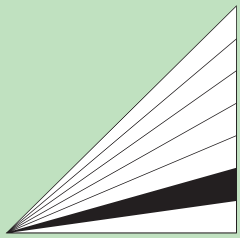
Altitude (masl)

- [ ] >4000
- [ ] 3000–4000
- [ ] 2500–3000
- [ ] 2000–2500
- [ ] 1500–2000
- [x] 1000–1500
- [ ] 500–1000
- [ ] 100–500
- [ ] <100

Landform



Slope (%)



Soil depth (cm)

- [ ] 0–20
- [ ] 20–50
- [x] 50–80
- [ ] 80–120
- [ ] >20

Growing season(s): two
Soil texture: medium (loam)
Soil fertility: high
Topsoil organic matter: medium
Soil drainage/infiltration: good

Soil water storage capacity: medium
Groundwater table: <50 m
Availability of surface water: poor/none
Water quality: good
Biodiversity: high

Tolerant of climatic extremes: increases in seasonal rainfall, heavy rainfalls
Sensitive to climatic extremes: increases in temperature, decreases in the length of the growing period
If sensitive, what modifications were made/are possible: none

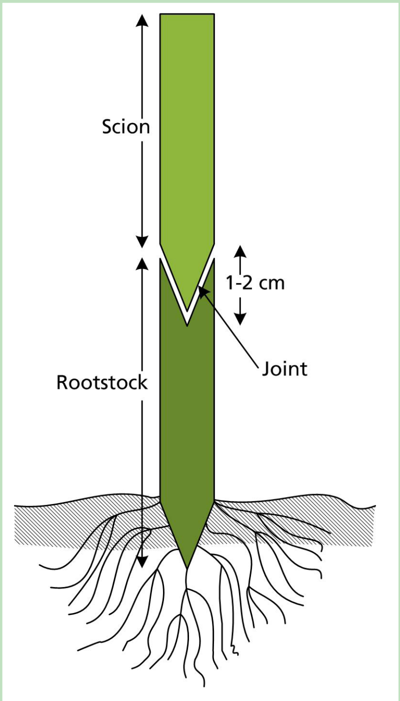
Human environment

Crop land per household (ha)

- [ ] <0.5
- [x] 0.5–1
- [ ] 1–2
- [ ] 2–5
- [ ] 5–15
- [ ] 15–50
- [ ] 50–100
- [ ] 100–500
- [ ] 500–1000
- [ ] 1000–10000
- [ ] >10000

Land user: individual/households
Population density: 200–500 persons per km²
Annual population growth: 0.5–1%
Land ownership: individual/titled
Land/water use rights: individual and communal
Relative level of wealth: poor (50%), average (30%), rich (20%)
Importance of off-farm income: 10–50% of total
Access to service and infrastructure: moderate to high

Market orientation: mixed subsistence and commercial
Mechanization: animal traction
Livestock grazing on cropland: yes, a little
Livestock density: medium
Purpose of forest/woodland use: na
Types of other land: na



Technical drawing
Schematic diagram of a tomato scion grafted on to the rootstock of a wild eggplant.
(A. K. Thaku)

Implementation activities, inputs and costs

Establishment activities

1. **Prepare the land:** Plough the soil two to three times and then plank; add well decomposed compost or farmyard manure (25–30 quintal per 338 m^2), di-ammonium phosphate (DAP) and potash (at 15 kg each per 338 m^2), and zinc and borax (0.5 kg each per 338 m^2), and mix into the soil.
2. **Prepare scions:** Sow seeds to a depth of 0.5 cm, cover with fine soil, and add biomulch. Remove mulch as soon as the seeds begin to grow.
3. **Prepare rootstock:** Grow wild eggplant seed (*Solanum sysimbrifolium*) in multi-cell trays and transplant at the 2–3 leaf stage into individual 10x15 cm (4 x 6 inch) polypots.
4. **Grafting:** Carry out grafting when the stalks of both the scion and rootstock plants are about the thickness of a pencil.
   - Cut the upper part of the rootstock and lower part of the scion and remove leaves and spines. The scion should have 2 or 3 upper leaves only.
   - Make a 1–2 cm long V-shaped notch in the upper portion of the rootstock.
   - Cut the tip of the scion into a 1–2 cm inverted V-shape.
   - Fit the scion into the root stock and bind the two together with the help of a grafting clip, parafilm tape, or a section of vinyl tubing to protect it from direct contact with water and air.
   - Keep grafted seedlings in their polypots in a closed polyhouse (grafting chamber) for 7–10 days at a temperature of 25–30˚C and humidity of 80–85%. Approximately 500 transplanted seedlings can be kept in 5 x 2.7 m grafting chamber.
5. **Transplant grafted seedlings:** Plant out seedlings at their final location. The planting distance depends on the tomato variety. For example, Srijana tomatoes are spaced 90 cm (R-R) x 60 cm (P-P).

Note: For more eco-friendly production, chemical fertilizers can be replaced by biofertilizers.

Establishment inputs and costs per 500 m^2

Inputs	Cost (USD)	% met by land user
Labour (5 person days)	21	100%
Equipment		
- spade, scissors, sharp scalpel, multi cell tray, hoe, plough	22	100%
Materials		
- polypots, grafting chambers, parafilm tape, sprayer	225	100%
Agricultural		
- seed	28	
- manure	65	
- fertilizer	17	
- pesticide	21	
- plant tonic	7	
TOTAL	**406**	**100%**

Maintenance/recurrent activities

1. Both scion and rootstock seeds are watered after sowing. The seedlings are monitored and watered as needed.
2. After transplanting, the grafted seedlings are watered the next day and twice weekly thereafter. As the plantlets mature, they are watered at 10-day intervals and the surface of the soil is mulched. The moisture level in the soil is monitored throughout the cropping period.
3. Top dressing with biofertilizers (N, P, K, and vesicular arbuscular mycorrhiza VAM) and bio-hume is applied to the root zone.

Maintenance/recurrent inputs and costs per 500 m^2 per year

Inputs	Cost (USD)	% met by land user
Labour (16 person days)	68	100%
Materials		
- electricity and water charges	8.5	100%
Agricultural		
- seed, manure, fertilizer, and pesticides	68	100%
TOTAL	**144.5**	**100%**

Remarks:
- All costs and amounts are rough estimates by the technicians and authors. Exchange rate USD 1 = NPR 72 in May 2011

Assessment

Impacts of the technology

Production and socioeconomic benefits

+++	Increased crop yield by 50%
+++	Increased farm income, by as much as 2–3 times
++	Moisture is maintained in the soil
++	Increase resistance towards pests and disease

Production and socioeconomic disadvantages

none

Socio-cultural benefits

+++	Improved food security and self-sufficiency by 200%

Socio-cultural disadvantages

none

Ecological benefits

+++	Increased biological pest disease control by 90%

Ecological disadvantages

none

Off-site benefit

none

Off-site disadvantages

none

Contribution to human wellbeing/livelihood

none

Benefits/costs according to the land user

Benefits compared with costs	short-term	long-term
Establishment	negative	positive
Maintenance/recurrent	neutral	positive

Acceptance/adoption:
Most (90%) of the farmers are implementing the technology voluntarily and there is a spontaneous trend for adoption. In the area studied, about 20–30 households per year are adopting this technology.

Concluding statements

Strengths and ➔how to sustain/improve	**Weaknesses** and ➔how to overcome
The technology is highly effective at controlling pests and disease. ➔ The wild eggplant rootstocks are somewhat difficult to graft because they are spiny. Spine-free rootstock seedlings would be easier to graft.	Grafting is time consuming and difficult because wild eggplant root-stock plants are spiny. ➔ Need more research to identify other possible rootstock plants.
The grafted seedlings themselves are a good source of income for farmers. ➔ Create awareness among farmers and encourage nurseries to provide grafted seedlings. Support farmers during the start-up stage.	Grafting can be expensive and requires an initial investment in training; specialized materials are needed. Technically demanding, needs practise. Specialized materials are difficult to get. ➔ Nurseries need to be supported and need to have access to specialized materials on time.

Key reference(s): None

Contact person(s): Mr. Komal Pradhan, IDE, Bakhundole, Lalitpur Tel: +977 1 5520943, kpradhan@idenepal.org; Purusottam Prasad Gupta, formerly IDE Nepal, currently NEAT project; Tel: 9847301749 (M); Email: puru-sottam_gupta@yahoo.co.in

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Left: Structure used for vermicomposting showing above ground bin, cover, and shed (Samden Sherpa)
Right: Ready to use vermicompost (Samden Sherpa)

Vermicomposting

Nepal: गड्यौला प्रयोग गरी मल बनाउने प्रबिधि

Vermicomposting or worm composting is a simple technology for converting biodegradable waste into organic manure with the help of earthworms.

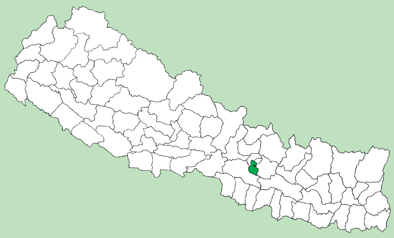
Earthworms are valued by farmers because, in addition to aerating the soil, they digest organic matter and produce castings that are a valuable source of humus. Vermicomposting, or worm composting is a simple technology that takes advantage of this to convert biodegradable waste into organic manure with the help of earthworms (the red worm *Eisenia foetida*) with no pile turning, no smell, and fast production of compost. The earthworms are bred in a mix of cow dung, soil, and agricultural residues or predecomposed leaf-litter. The whole mass is converted into casts or vermicompost, which can be used as a fertilizer on all types of plants in vegetable beds, landscaping areas, or lawns.

Worms are so effective at processing organic waste that they can digest almost half their own weight in debris every day. Vermicomposting is a simple composting process that takes advantage of what earthworms do naturally, but confines the worms to bins making it easier for farmers to feed them and to harvest their nutrient-rich compost. Since all worms digest organic matter, in principle, any type of worm can be used; however, not all are equally well adapted to living in bins since some worms prefer to live deep in the soil while others are better adapted to living closer to the surface. The red worm (*Eisenia foetida*) is ideal for vermicomposting because its natural habitat is close to the surface and it is accustomed to a diet rich in organic matter, this makes it ideally suited to digesting kitchen scraps and to living in bins.

Vermicomposting can be carried out in different types of containers. There are only a few requirements for a good worm pit, the most important being good ventilation; the pit needs to have more surface area than depth (wide and shallow) and it needs to have relatively low sides. The base of the worm pit is prepared with a layer of sand then alternating layers of shredded dry cow dung and degradable dry biomass and soil are added. Under ideal conditions, 1,000 earthworms can covert 45 kg of wet biomass per week into about 25 kg of vermicompost.

Worm castings contain five times more nitrogen, seven times more phosphorous, and eleven times more potassium than ordinary soil, the main minerals needed for plant growth. The vermicompost is so rich in nutrients that it should be mixed 1:4 with soil for plants to be grown in pots and containers. Vermicompost should not be allowed to dry out before using.

Note: This type of vermicomposting is sometimes referred to as 'Pusa' vermicomposting because it was popularized in South Asia by the Rajendra Agricultural University located in Pusa, Bihar, India.



WOCAT database reference: QT NEP 36
Location: ICIMOD Knowledge Park at Godavari, Lalitpur District, Nepal
Technology area: Demonstration plot
Conservation measure(s): Agronomic and management
Land Use: Annual/perennial cropping on rainfed agricultural land
Stage of intervention: Prevention of land degradation
Origin: Innovation through experiment and research
Climate: Subhumid/temperate
Other related technology: Improved compost preparation (QT NEP 7), Better quality farmyard manure through improved decomposition(QT NEP 8), Improved farmyard manure through sunlight, rain and runoff protection (QT NEP 9), Black plastic covered farmyard manure (QT NEP 16)
Compiled by: Samden Lama Sherpa, ICIMOD
Date: June 2011, updated March 2013

The technology was documented using the WOCAT (www.wocat.org) tool.

Classification

Land use problems

Crop productivity is limited by poor soil fertility, intense cropping, and a scarcity of irrigation water. Farmers notice a marked decrease in the health of their crops and degraded soil conditions when chemical fertilizers are overused. Vermicomposting is a low input response to this problem.

Land use


Annual cropping


Perennial cropping

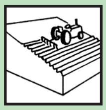
Climate


Subhumid/temperate

Degradation


Chemical degradation: fertility decline

Conservation measures


Agronomic measure

Stage of intervention

- ■ Prevention of land degradation
- □ Mitigation/reduction
- □ Rehabilitation

Origin

- □ Land users' initiative
- ■ Experiments: demonstration externally introduced
- □ Other (specify)

Level of technical knowledge

- □ Low
- ■ Medium: land users, technicians
- □ High

Main causes of land degradation: Improper soil management

Technical function/impact

Main:
- Improves soil fertility
- Increases available nutrients
- Increases available nutrients

Secondary:
- Improves structure of topsoil
- Stabilizes the soil

Environment

Natural environment

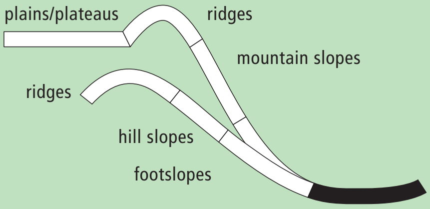
Average annual rainfall (mm)

- □ >4000
- □ 3000–4000
- □ 2000–3000
- ■ 1500–2000
- □ 1000–1500
- □ 750–1000
- □ 500–750
- □ 250–500
- □ <250

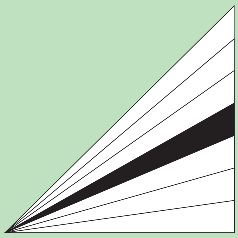
Altitude (masl)

- □ >4000
- □ 3000–4000
- □ 2500–3000
- □ 2000–2500
- ■ 1500–2000
- □ 1000–1500
- □ 500–1000
- □ 100–500
- □ <100

Landform



Slope (%)



Soil depth (cm)

- ■ 0–20
- □ 20–50
- □ 50–80
- □ 80–120
- □ >20

Growing season(s): not relevant
Soil texture: medium loam
Soil fertility: medium
Topsoil organic matter: high (>3%)
Soil drainage/infiltration: medium
Soil water storage capacity: medium

Groundwater table: <5 m
Availability of surface water: good
Water quality: good for drinking and agricultural use
Biodiversity: high (695 species of flora and 230 species of fauna have been documented within the Park's 30 ha area)

Tolerant of climatic extremes: active in warm climates
Sensitive to climatic extremes: sensitive to too hot or too cold temperatures
If sensitive, what modifications were made/are possible: The chamber should be covered and shaded; earthworms should be shielded from direct sunlight. In winter, the pit can be moved to a greenhouse.

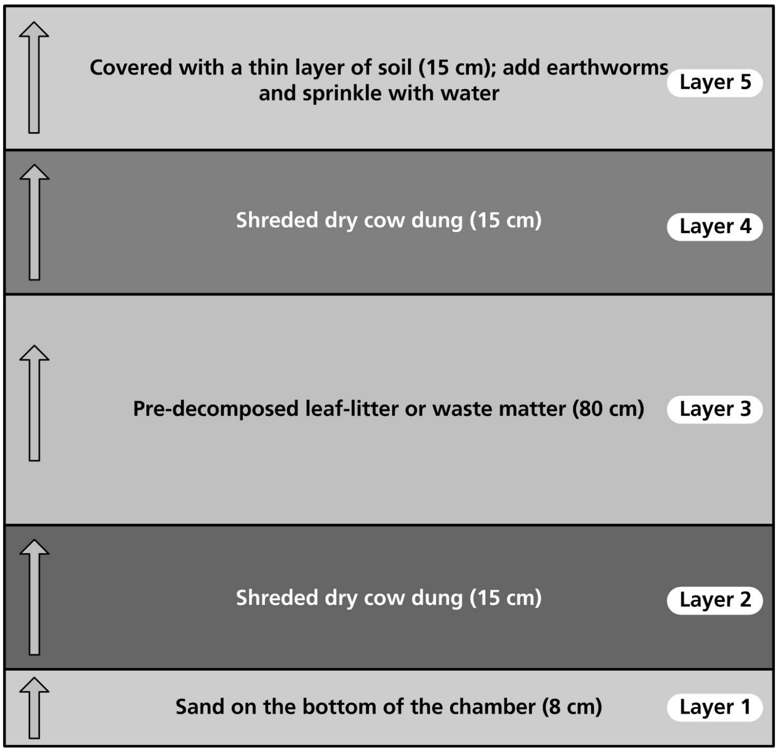
Human environment

Crop land per household (ha)

- ■ <0.5
- ■ 0.5–1
- □ 1–2
- □ 2–5
- □ 5–15
- □ 15–50
- □ 50–100
- □ 100–500
- □ 500–1000
- □ 1000–10000
- □ >10000

Land user: for demonstration and experiment
Population density: >10 persons per km²
Land ownership: government
Land/water use rights: community/individual
Relative level of wealth: neighbouring communities are poor
Importance of off-farm income: >50% of all households around the demonstration site have off-farm income
Access to service and infrastructure: labour available; road access used to transport crops

Market orientation: mixed subsistence and commercial in the vicinity of the demonstration site
Mechanization: manual and animal traction
Number of livestock: in the vicinity of the demonstration site poor households may have a few goats whereas wealthier farmers often own several cattle
Purpose of forest / woodland use: fodder, fuelwood
Types of other land: scrubland
Level of technical knowledge required: some training required



Establishing a vermicompost pit
Diagram showing the layers needed to set up a vermicompost pit. Note that the middle layer is the thickest; the worms start here and eat both upwards and downwards. It is best to house the pit under a thatched or plastic roof in order to shield it from excessive sunshine and rain.
(AK Thaku)

Implementation activities, inputs and costs

Establishment activities

A low cost pit can be constructed with bricks on a moist or shaded site. A typical outdoor pit can measure 4 m long, 1 m wide and 0.75 m high. If bricks are not available, stones can be used for the pit construction; alternatively, a wooden or bamboo box or a plastic tray can also be used. Vermicompost pits are best started during the summer months.

A thatched roof was built over the pit to help retain moisture in the heap at a level of approximately 40–50%, as well as to maintain an optimal temperature of about 20–30°C.

Sand, soil, cow dung, and leaf litter are piled up as shown in the diagram.

Establishment inputs and costs per unit

Inputs	Cost (USD)	% met by land user
Labour (10 person days)	50	
Materials		
- bricks and cement	70	
- dry cow dung	10	
- plastic sheet/bamboo	70	
- earthworms (2,000)	60	
TOTAL	**260**	**0%**

Maintenance/recurrent activities

- Water regularly
- Collect and harvest vermicompost

The pit is watered regularly. After five to six weeks, the top layer is removed and piled in one corner of the pit. After a few days, the worms will have borrowed down to the bottom of this pile and the compost can be harvested. The compost prepared in the pit should be harvested within 6 months and the pit refurbished as for the first set as discussed above.

Maintenance/recurrent inputs and costs per unit per year

Inputs	Cost (USD)	% met by land user
Labour (5 person days)	25	
Materials		
- dry cow dung	5	
- water pipe	10	
TOTAL	**40**	**0%**

Remarks:

- All costs and amounts are rough estimates by the technicians and authors. Exchange rate USD 1 = NPR 72 in June 2011.
- This was a demonstration project conducted by ICIMOD.

Assessment

Impacts of the technology

Production and socioeconomic benefits

+++	Reduced expenditure on chemical fertilizers
+++	Improved soil fertility
+++	Can be used to produce organic crops

Production and socioeconomic disadvantages

−	Earthworms need to be purchased from outside
−	The vermicompost pit needs to be watered and maintained regularly.

Socio-cultural benefits

none

Socio-cultural disadvantages

none

Ecological benefits

+++	Reduced use of chemical fertilizers

Ecological disadvantages

−	If forest leaf-litter is removed for vermicomposting it impoverishes the forest soil

Off-site benefit

+++	Reduced dependence on external inputs

Off-site disadvantages

none

Contribution to human wellbeing/livelihood

+++	Provides employment opportunities. Quality compost helps to improve the soil and increases crop production.

Benefits/costs according to the land user

Benefits compared with costs	short-term	long-term
Establishment	positive	positive
Maintenance/recurrent	positive	positive

Approximately 2 tonnes of vermicompost can be produced in six months from the size of pit mentioned above with 2000 earthworms. The total cost to produce 2 tonnes of vermicompost is approximately USD 300. The farmer can realize a benefit of approximately USD 700 from selling the vermicompost and USD 300 from selling the excess worms, for net profit of USD 700.

Acceptance/adoption:

Vermicomposting training was provided to farmers in Nuwakot, Rasuwa, Godavari, and Bishankhunarayan VDCs by ICIMOD staff in collaboration with local NGOs. More than 60% of the farmers who received training adopted vermicomposting on their own farms and they have also started selling worms to other farmers. The technology has been adopted by others who have visited the ICIMOD Knowledge Park at Godavari but most of these are just interested in introducing it on a small scale, such as, to produce vermicompost from kitchen waste for household use in their own gardens. The participants were also taught how to collect local earthworms to use for composting.

Drivers of adaptation of the technology

- A simple technology and easy to implement
- Local earthworms can be used.
- Not expensive; farmers can construct pits or uses wooden boxes or plastic trays.
- Produces high quality compost with a high concentration of nutrients
- Helps to reduce pests in the soil
- Can be scaled up to produce compost commercially

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
The use of vermicompost reduces the need for chemical fertilizers and reduces dependence on outside sources. → Promote the technology by disseminating it to a large number of farmers on both small and big farms.	Purchasing earthworms from outside may be expensive for farmers. → Farmers can be encouraged to harvest local earthworms for composting.
Vermicomposting does not require keeping livestock. → It is considered to be a low-cost alternative that uses local earthworms and materials to produce compost.	Making compost from earthworms is not very popular in rural areas. → Create greater awareness on how earthworms can be used to compost leaf-litter and other kitchen waste.
On-farm composting saves the transportation cost needed to deliver compost to the farm.	

Key reference(s): Vermicomposting: Journey to forever organic garden (no date) [online]. http://journeytoforever.org/compost_worm.html (accessed 14 November 2012)
Contact person(s): Mr Samden Lama Sherpa, ICIMOD, P.O.Box 3226, Kathmandu, Nepal; Tel: +977 1 5003222; Email: ssherpa@icimod.org
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Left: No-till garlic cultivation in Gadariya VDC, Kailali District, Nepal (Krishna Lamsal)
Right: Well-established garlic plants grown by the no-till method. Note that the original mulch is still in place helping to retain moisture. (Krishna Lamsal)

No-till garlic cultivation

Nepal: खनजोत नगरि लसुन खेति

No-till is a farming system in which the seeds are planted directly into untilled soil which still contains the previous crop residues. No-till cultivation of garlic is practised in the tropical lowland districts of western Nepal where garlic is sown directly into the soil after the paddy is harvested.

No-till* methods minimize soil disturbance and allow crop residues or stubble to remain on the ground instead of being removed or dug into the soil. As practised in the western Terai of Nepal, the seedbed is prepared by leaving a 3–5 cm thick layer of rice paddy crop residue on the soil surface after the paddy harvest. Garlic seed is planted directly into the soil soon after the paddy is harvested at a spacing of approximately 15 cm and the entire field is then covered with a 10 cm (or more) layer of hay. The seeds germinate with the help of the ambient moisture. The frequency and timing of irrigation depends on need, but since there has been no tillage and the ground is covered with mulch, much of the ambient moisture is retained in the soil. The mature garlic is harvested in February–March. This technology is gaining in popularity because farmers can directly see the economic benefit of not having to till the soil.

No-till methods are important from the standpoint of environmental farming for a number of reasons. The fact that the soil is not tilled after the paddy is harvested and remains covered with crop residues leads to efficient erosion control (up to 90%) and increased biological activity in and on the soil. The technology helps to conserve moisture in the soil, to improve the infiltration of water (up to 60%), and to reduce soil compaction, and overall, it requires less energy for cultivation (Derpsch et al. 2010). Increasing soil organic matter also helps to sequester carbon and contributes to reducing agricultural greenhouse gas emissions; ultimately, it supports increased production and resilience to climate change. In addition to keeping carbon in the soil, in a recent study, no-till farming was found to reduce nitrous oxide (N_2O) emissions by 40–70%, depending on the rotation.

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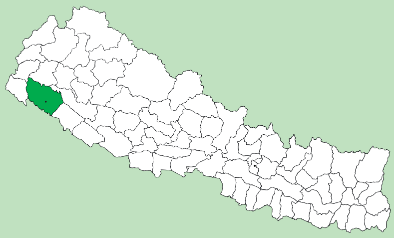
* No-till in this context means the soil is not tilled after the paddy is harvested and before the garlic seeds are planted. After the garlic is harvested, the soil is tilled before the next crop is planted. No-till is a form of conservation tillage, which refers to methods that leave at least 30% of crop residues in place.



WOCAT database reference: QT NEP 39
Location: Gadariya VDC, Kailali District, Nepal
Technology area: Approximately 1–10 km^2
Conservation measure(s): Agronomic
Land Use: Annual cropping
Stage of intervention: Mitigation
Origin: Innovative; this is a local initiative started about 10 years ago
Climate: Subhumid/subtropical
Related approach: Learning about no-till methods through farmer-to-farmer dissemination (QA NEP 39)
Compiled by: Krishna Lamsal, LI-BIRD
Date: July 2011, updated March 2013

The technology was documented using the WOCAT (www.wocat.org) tool.

ICIMOD LI-BIRD WOCAT

Classification

Land use problems
Water scarcity due to drying out of water sources, irregular precipitation, and soil erosion, are the major land use problems.

Land use

Annual cropping mixed rainfed - irrigated

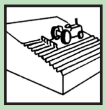
Climate

Subhumid/ subtropical

Degradation

Water erosion: loss of topsoil by water

Conservation measures



Agronomic measure

Stage of intervention

- □ Prevention
- ■ Mitigation/reduction
- □ Rehabilitation

Origin

- ■ Land users' initiative
- □ Experiments/research
- □ Externally introduced
- □ Other (specify)

Level of technical knowledge

- □ Low
- □ Medium
- ■ High: land users and technicians

Main causes of land degradation: Poor soil management, changes in seasonal rainfall, changes in temperature

Technical function/impact

Main:
- Increases the availability of nutrients (supply, recycling)
- Increases the amount of organic matter in the soil

Secondary:
- Increases or retains water stored in the soil
- Increases infiltration of water

Environment

Natural environment

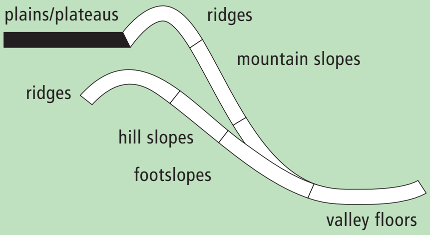
Average annual rainfall (mm)

- □ >4000
- □ 3000–4000
- □ 2000–3000
- ■ 1500–2000
- ■ 1000–1500
- □ 750–1000
- □ 500–750
- □ 250–500
- □ <250

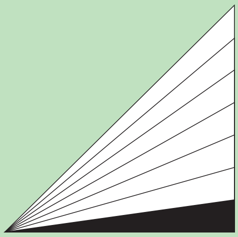
Altitude (masl)

- □ >4000
- □ 3000–4000
- □ 2500–3000
- □ 2000–2500
- □ 1500–2000
- □ 1000–1500
- □ 500–1000
- ■ 100–500
- □ <100

Landform



Slope (%)



Soil depth (cm)

- □ 0–20
- □ 20–50
- □ 50–80
- □ 80–120
- ■ >20

Growing season(s): three
Soil texture: fine/heavy (clay)
Soil fertility: high
Topsoil organic matter: high (>3%)
Soil drainage/infiltration: medium

Soil water storage capacity: high
Groundwater table: 10 m approx.
Availability of surface water: poor/none
Water quality: for agricultural use only, poor drinking water quality
Biodiversity: low

Tolerant of climatic extremes: decreases in seasonal rainfall
Sensitive to climatic extremes: increases in: temperature, seasonal rainfall, the number of heavy rainfall events (intensity and amount); windstorms, dust storms, droughts, and dry spells
If sensitive, what modifications were made/are possible: can be made more adaptive to the changing context by using improved varieties of seeds which are resistant (tolerant) to environmental stresses like drought, increases in temperature, or heavy precipitation.

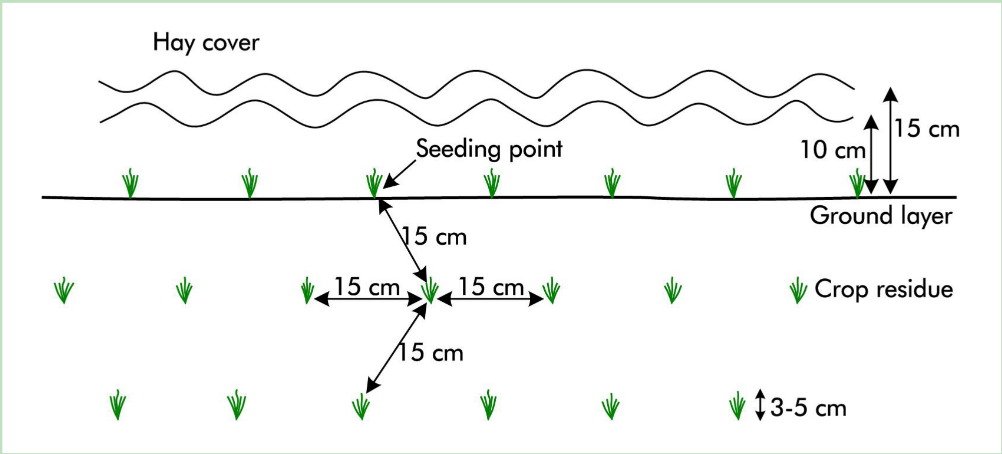
Human environment

Crop land per household (ha)

- □ <0.5
- □ 0.5–1
- ■ 1–2
- □ 2–5
- □ 5–15
- □ 15–50
- □ 50–100
- □ 100–500
- □ 500–1000
- □ 1000–10000
- □ >10000

Land user: individual/household (small scale and average, mixed)
Population density: >500 persons per km^2
Annual Population growth: 2–3%
Land ownership: individual, not titled
Land/water use rights: individual, water: communal (organized)
Relative level of wealth: 80% are average and 5% are poor
Importance of off–farm income: 10–50% of all income

Access to service and infrastructure: low to high
Market orientation: mixed (subsistence and commercial)
Mechanization: only for cropland; elsewhere: manual labour, animal traction
Livestock grazing on cropland: no
Livestock density: NA
Purpose of forest/woodland use: NA



Technical drawing
No-till garlic cultivation in fields where paddy has just been harvested. (Krishna Lamsal, AK Thaku)

Implementation activities, inputs and costs

Establishment activities

Not applicable as the planting area was established long ago.

Establishment inputs and costs per ha

Inputs	Cost (USD)	% met by land user
Labour (person days)		
Equipment		
Materials		
Agricultural		
TOTAL		

Maintenance/recurrent activities

Maintenance and recurrent activities are minimal. The seedlings need to be watered, fertilized, and weeded.

Maintenance/recurrent inputs and costs per ha per year

Inputs	Cost (USD)	% met by land user
Labour (6 person days)	25.40	100%
Materials		
- mulch (hay) (60 kg)	14.00	100%
Agricultural		100%
- seed (10 kg)	7.00	
- manure (200 kg)	2.80	
- fertilizer (1 kg)	0.70	
- irrigation	1.40	
TOTAL	**51.30**	**100%**

Remarks:

- All costs and amounts are rough estimates by the technicians and authors. Exchange rate USD 1 = NPR 71 in July 2011

Assessment

Impacts of the technology

Production and socioeconomic benefits

+ + +	Increased crop yield
+ + +	Decreased workload
+ +	Reduced risk of production failure because moisture is retained
+ +	Diversification of income sources; powdered garlic is considered a cash crop as it has medicinal value
+ +	Reduced labour costs

Production and socioeconomic disadvantages

none

Socio-cultural benefits

+ +	Improved conservation/erosion knowledge

Socio-cultural disadvantages

none

Ecological benefits

+ + +	Increased moisture in the soil
+ + +	Reduced soil loss
+ +	Increased nutrient cycling and recharge
+	Contributes to reduced emission of carbon and greenhouse gases

Ecological disadvantages

none Niche specific

Off-site benefit

none

Off-site disadvantages

none

Contribution to human wellbeing/livelihood

+ + +	Increased farm income, reduced risk of crop production failure, and reduced work load

Benefits/costs according to the land user

Benefits compared with costs	short-term	long-term
Establishment	positive	positive
Maintenance/recurrent	positive	positive

Acceptance/adoption:
This technology is widely adopted and practised by a large percentage of the households. All the households who practise this technology do so at their own cost. This technology has become popular among the neighbouring communities and districts.

Concluding statements

Strengths and ➔how to sustain/improve	**Weaknesses** and ➔how to overcome
Decreased soil erosion, diversification of income sources, and livelihood options; reduced expenses on agricultural inputs ➔ Water needs to be available for irrigation and market linkages are needed to be able to fully profit from this cash crop.	
Soil conservation, improves water infiltration, increases organic matter in the soil; saves effort and time ➔ More awareness of the conservation value of no-till methods	
Carbon sequestration, reduced agricultural greenhouse gas emissions, and climate change adaptation ➔ Improved varieties of garlic that have stress resistant characteristics would help adaptation to climate change and would enhance environmental benefits.	

Key reference(s): Derpsch, R; Friedrich, T; Kassam, A; Hongwen, L (2010) 'Current status of adoption of no-till farming in the world and some of its main benefits.' *Int J Agric & Biol Eng* 3 (1): 1–25. http://www.fao.org/ag/ca/CA-Publications/China_IJABE.pdf
Contact person(s): Krishna Lamsal, Local Initiatives for Biodiversity, Research and Development (LI-BIRD), P.O.Box 324, Gairapatan, Pokhara
Tel :+977 61 535357/526834, Fax +977 061 539956; Email: info@libird.org, www.libird.org
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