Left: Overview of improved terraces with soil and water conservation (SWC) grasses on riser margins. Maize was the major crop before the terraces were improved. Now vegetables and rice are grown. (K.M. Sthapit)
Right: Napier grass *(Pennisetum purpureum)* along the margins of an improved terrace riser. (K.M. Sthapit)

Improved terraces

Nepal: गह्रा सुधार

Hillside forward-sloping terracing and stabilisation using structural and vegetative measures

This technology addresses the soil erosion and water runoff problems associated with traditional outward-sloping terraces by reshaping the land into a series of level or gently sloping platforms across the slope. This technology is a variant of sloping land agricultural technology (SALT) or contour hedgerow technology. Nitrogen-fixing hedgerow species and quality fodder grass species, which bind the soil, are cultivated along terrace riser margins to improve terrace stability. This also enhances soil fertility and increases fodder availability. The plants are grown in either single or multiple layers. The practice is applied under rainfed conditions and is culturally acceptable and affordable. After establishment, the technology also addresses the problems of fodder scarcity making it easier and less time consuming for women and girls to gather fodder.

The hedgerow and grass species are established between January and June. Complete establishment of this technology may take one year. The first step in creating the terraces is to build retaining walls using cement bags filled with soil which are then supported with bamboo cuttings along the contour (= future terrace risers). This divides the land into the planned terrace sections. The length and width of the terraces depends on the size and shape of the original field. Secondly, the soil is excavated from the upper part of the terraces and is used to build up the lower part above and behind the terrace riser wall to create a level bed. The fertile top soil must be kept aside and later spread over the newly terraced fields. The final step is to plant grass and hedgerow species on the outermost margins of the terrace above the risers.

Maintenance involves slicing the terrace risers once or twice a year with a spade, and smoothing off rills that appear on the surface of terraces after the premonsoon and monsoon periods. Hedgerows should be cut regularly but not more than twice a year, normally to a height of about 50 cm. Grasses should be cut about once to twice a month depending on their rate of growth.

The technology is applied under humid subtropical climate conditions (1300 mm annual rainfall with about 80% of it falling in the monsoon months of June - September). The case study area has hill slopes of 16-30% that are mostly highly erodible red soils (FAO classification: luvisols).

WOCAT database reference: QT NEP2
Location: Kubinde village, Jhikhu Khola watershed, Kabhrepalanchok district
Technology area: 0.02 km^2
SWC measure: Structural and vegetative
Land use: Annual cropping
Climate: Humid subtropical
Related approach: Improving terraces with farmers, QA NEP2
Compiled by: Madhav Dhakal, ICIMOD
Date: February 2003, updated November 2006

General comments: Terrace improvement is an age old practice by which sloping hill land is mechanically converted into a series of level or nearly level terraces. It is commonly found in low to middle elevation ranges under both irrigated and rainfed conditions. However, the practice of riser stabilisation through vegetative means is not common.

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

ICIMOD

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Swiss Agency for Development and Cooperation SDC

WOCAT

Classification

Land use problems

The major land use problem in the area documented is the small per capita cropping landholding size. The fields are mostly rainfed and have low soil fertility and acidity problems and are susceptible to erosion. The high intensity of rainfall leads to considerable soil loss (rill and gully erosion) at the beginning of rainy seasons.

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

Annual crops: maize (before SWC applied), vegetables and rice (after SWC)

Humid subtropical

Water erosion: loss of top soil, gullying

Physical degradation: soil moisture problem

Structural: reshaping surface, building walls

Vegetative: grasses/ hedgerow spenes/shrubs along risers

Technical function/impact

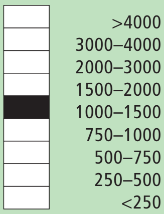
Main:
- reduction of slope angle
- reduction of slope length
- control of concentrated runoff (impedes/retards)

Secondary:
- increase in soil fertility
- increase/maintenance of water stored in soil
- increase of infiltration

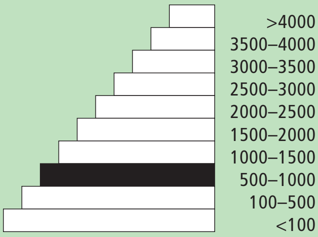
Environment

Natural environment

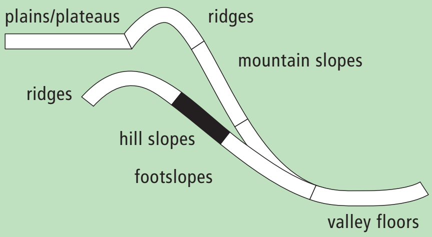
Average annual rainfall (mm)



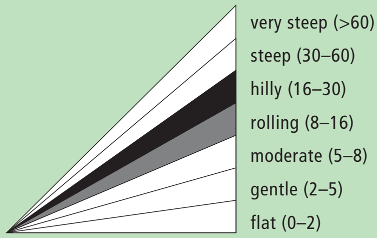
Altitude (masl)



Landform

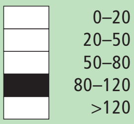


Slope (%)



Applied (large extent) Applied (medium extent)

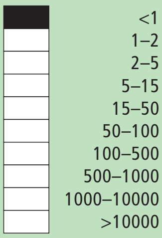
Soil depth (cm)



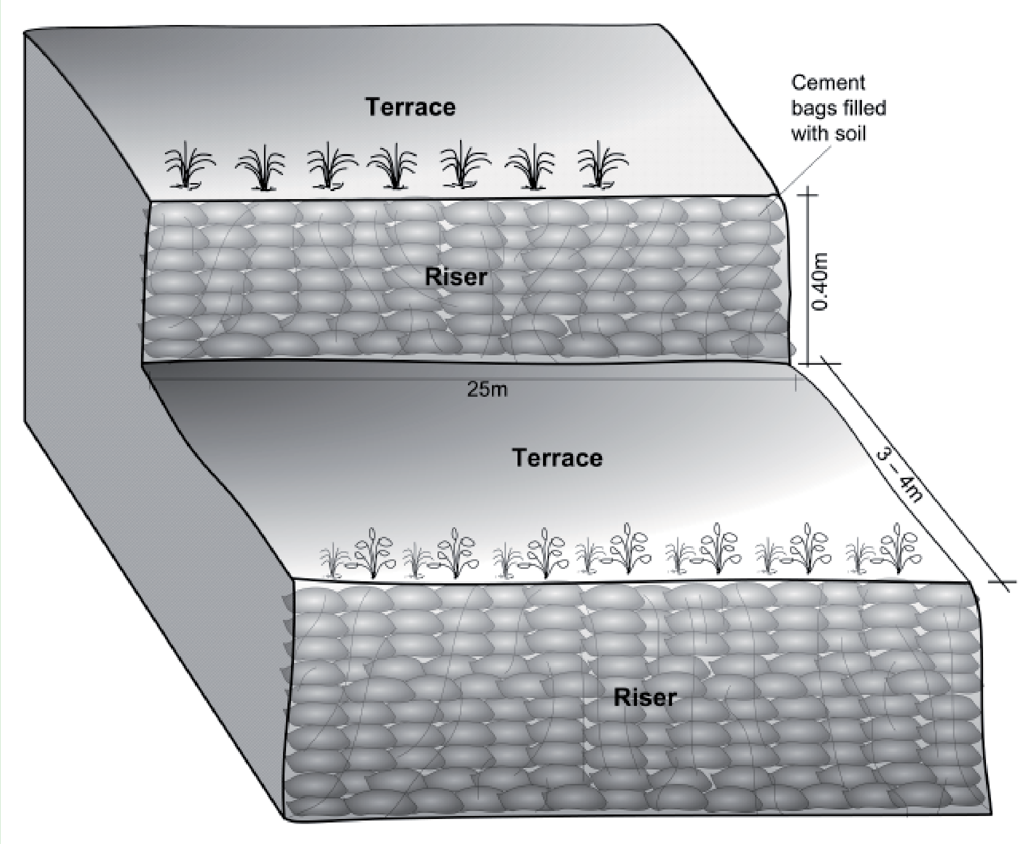
Growing season: 150 days (June to October) and 120 days (November to February)
Soil fertility: low
Soil texture: mostly fine (clay)
Surface stoniness: no loose stones
Topsoil organic matter: low to medium
Soil drainage: good
Soil erodibility: very high

Human environment

Mixed land per household (ha)



Land use rights: individual
Land ownership: individually owned/titled
Market orientation: mostly subsistence (self-supply), mixed (part subsistence and part commercial vegetable growing)
Level of technical knowledge required: field staff/extension worker: high, land user: moderate
Number of livestock: not relevant
Importance of off-farm income: In most farm households off-farm income plays at least a minor and increasingly a major role. Occasional opportunities for off-farm income present themselves in the form of daily labour wages. Some households' members receive regular salaries whilst an increasing number of Nepalis are working in India, the Middle East, Malaysia, and elsewhere and sending remittance incomes home.



Technical drawing
Schematic view after intervention
[terracing and vegetative measures]
Riser slope: 75^0
Terrace slope: ~ 2^0

Implementation activities, inputs and costs

Establishment activities

Manual labour and local agricultural tools are used to establish this technology. The technology is best established between January and June although complete establishment may take one year. The major steps are as follows.

1. Establishment of risers, using cement bags filled with soil and planting bamboo cuttings for terrace stabilisation.
2. Terrace levelling: The length and width of the terraces depends on the size and shape of the field. Excavate soil from the upper part of the terrace field and use it to build up the lower part behind the terrace riser wall to create a level platform/bed.
3. Planting of grasses and hedgerow species on the outward margins of the terrace fields above the risers.

Establishment inputs and cost per ha (2003)

Inputs	Cost (US$)	% met by land user
Labour (312 person days)	970	50%
Technician	10.5	0%
Equipment		
- Tools (spade, shovel)	92	100%
Materials		
- Empty cement bags (1600)	80	50%
- Bamboo cuttings (80)	80	50%
Agricultural		
- Grass seeds (2kg)	25	0%
- Grass seedings (2500)	30	0%
TOTAL	**1287**	**51%**

Maintenance/recurrent activities

1. Surface and riser maintenance: smooth the surface/rills on the terrace field caused by monsoon and pre-monsoon rainfall. Terrace risers are sliced once or twice a year. All activities are performed manually using local agricultural tools like spades.
2. Hedgerow/grass maintenance: Hedgerows are cut regularly but not more than twice a year, normally a height of 50 cm is maintained. Grass is cut once or twice a month.

Maintenance/recurrent inputs and cost per ha per year (2003)

Inputs	Cost (US$)	% met by land user
Labour (100 person days)	310	100%
Equipment	20	100%
-		
Materials		
-		
Agricultural		
- Grass seeds (0.5kg)	6	100%
- Grass seedings (500)	6	100%
TOTAL	**342**	**100%**

Remarks: All costs and amounts are roughly estimated by the technicians and authors. Exchange rate US$1 = NRs 73 in 2006.

Assessment

Acceptance/adoption

Among 16 land user households, 6 households accepted the technology with incentives (about 50% subsidy from the project) and 10 households adopted it without any incentives. About 40% of the total land (0.02 km^2) was improved with subsidy being provided and 60% spontaneously.
The number of farmers applying the technology is increasing without further incentives. Others have shown interest in the technology but have not implemented it.

Drivers for adoption

- The technology addresses the direct needs of farmers of better land fertility, more crop and fodder production, and better retention of soil moisture.
- Technical support from projects and line departments
- Financial or material help for technology establishment

Constraints to adoption

- High cost of establishing the technology
- Farmers are not trained on all aspects of the technology
- Lack of incentives for poor farmers

Benefits/costs according to land users

The initial investment is high, but can be recovered within a short period due to yield increment and cash crop production.

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

Impacts of the technology*

Production and socioeconomic benefits

+ + +	Increased yield of maize crop by 100%.
+ +	Increased farm income by >100% due to higher yields and incorporation of market-orientated crops
+ +	Increased fodder production/quality

Production and socioeconomic disadvantages

-	Loss of land

Socio-cultural benefits

+	Strengthened community institution: formed terrace user group

Socio-cultural disadvantages

none

Ecological benefits

+ + +	Reduced soil loss due to levelled surface and hedgerow barrier
+ + +	Improved soil cover along risers
+ +	Increased soil moisture
+ +	Increased soil fertility near hedgerows
+ +	Enhanced biodiversity due to new crop/vegetable species

Ecological disadvantages

-	Appearance of pests like rats due to introduction of planted grasses like Napier grass

Off-site benefit

+ +	Fodder grass multiplication through farmer to farmer dissemination
+	Reduced downstream flooding
+	Reduced downstream siltation

Off-site disadvantages

-	Less nutrients downstream

* All changes in technology may have gender and equity implications and potentially affect the members of disadvantaged groups differently. This has not been assessed here but should be considered when recommending technology use.

Concluding statements

Strengths and ➔how to sustain/improve	**Weaknesses** and ➔how to overcome
Land productivity increased, maize, potato and bean production increased, vegetables and rice production started ➔ Irrigation facility could increase the production capacity of the terraces	In the first year of implementation, maize production was reduced due to soil amendment ➔ a phenomenon which is likely to occur with new terrace formation
Availability of grass/fodder (nitrogen fixing) increased. ➔ Planting horticultural fruits could increase farm incomes and so it should be promoted and more nitrogen fixing species (preferably local) should be tried out	Presently the vegetative technology is confined to terrace margins ➔it should be extended to the risers also
The price of land increased considerably from NRs 30,000 in 2001 (for 1 ropani – 508.5 sq. m) to between NRs 100, 000 and NRs 150,000 per ropani after the technology was established ➔ The price would increase further if irrigation facilities were installed	
The area of levelled terraces nearly doubled in Kubinde village from 2001 to 2003, which is an indicator of increased awareness of the benefits of soil and water conservation ➔ Experience sharing would help expand the area under improved terraces	

Key reference(s): ICIMOD (2002) *Hydro-meteorological Year Book of Jhikhu Khola Watershed.* Kathmandu: ICIMOD ■ Mathema, P.; Singh, B.K. (2003) *Soil Erosion Studies in Nepal: Results and Implications.* Kathmandu: Government of Nepal, Department of Soil Conservation and Watershed Management ■ Mathema, P. (2003) *Watershed Management in South Asia.* Kathmandu: Government of Nepal, Department of Soil Conservation and Watershed Management

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