Left: Irrigation of traditional paddy rice terraces; the water is drained from one terrace to the next through narrow openings. Note the pile of manure on the upper terrace ready for applying to the field (Hanspeter Liniger)
Right: Maintenance: farmer scraping/slicing the terrace riser; the material is then spread on the fields, improving soil fertility (Hanspeter Liniger)

Traditional irrigated rice terraces

Nepal: टारी खेत

Level bench terraces with risers protected by fodder grasses, used for the irrigated production of rice, potatoes and wheat

The level bench terrace is a traditional technology that makes irrigated crop production possible on steep, erosion-prone slopes. Most such terraces in Nepal were constructed by hand many generations ago; but some new land – mostly already under rainfed cultivation on forward sloping terraces – is still being converted into irrigated terraces. The initial costs for building the terraces are very high and there are high annual maintenance costs. The climate is humid subtropical, the slopes are steep (30-60%), and the soils generally have a sandy loam texture. Terraces are cropped by farmers who mostly have less than 0.5 ha of land each. Two to three annual crops are grown, with paddy rice during the monsoon followed by potatoes and/or wheat.

Terrace beds are usually 2-6m wide and are made as wide as possible to save labour without increasing the danger of slips and landslides. The terraces were originally surveyed by eye, but now a water-tube level is used to survey new terraces. Risers are 0.8-1.5m high with a small lip (20-25 cm). The slope of the riser varies from 80 to 160%, depending on the initial gradient of the hill. Stones are incorporated in the risers, if available, and grass species such as Bermuda grass *(Cynodon dactylon)* and Napier grass *(Pennisetum purpureum)* may be planted to help stabilise the terrace edges and for use as cattle fodder. The risers are compacted (with hoes) to improve ponding conditions for paddy rice. Twice a year the risers are scraped with a special tool: whilst preparing to plant paddy rice the lower parts of risers are sliced, with the upper part left protected with grasses against the monsoon rains; and at the time of planting wheat the whole riser (including the lip) is scraped and spread as green manure on the terrace.

Terraces are flooded with water for paddy rice cultivation, whilst smaller amounts of water are diverted into the fields for other crops. Excess water is drained to lower terraces through openings made in the lip filled with rice straw to stop too much sediment being washed down. The depth of water for rice – when flooded completely – is normally between 10 and 15 cm. Fertility is maintained by adding farmyard manure, by spreading the scraped soil from risers, and also from the sediment carried in the irrigation water. Nowadays, mineral fertilisers are also applied.

WOCAT database reference: QT NEP10
Location: Sankhu Bhulbu, Manmata subwatershed, Kathmandu district
Technology area: 1 km^2
SWC measure: Structural, vegetative and agronomic
Land use: Cropland
Climate: Humid subtropical
Related approach: Not documented (traditional technology)
Compiled by: Ramanand Bhattarai, District Soil Conservation Office, Lalitpur, Nepal
Date: November 2003, updated August 2004

General comments: Irrigated bench terraces are a very common traditional technology, widespread in Nepal on footslopes and across the mid hills of the Himalayas. There are close similarities with the paddy rice terraces of South East Asia in the Philippines, Indonesia, and China.

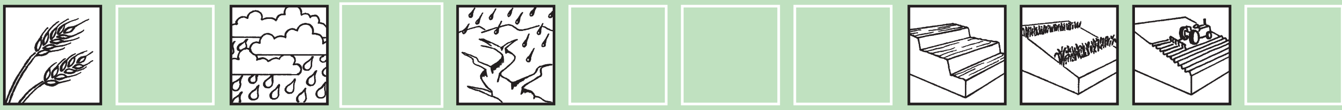
The technology was documented using the WOCAT (www.wocat.org) tool.

Classification

Land use problems

- steep slopes, not suitable for agriculture in their original state (better for forestry, agroforestry, horticulture, and fruit trees)
- small and scattered plots of land
- land users find chemical fertilisers and water expensive
- there is water scarcity from September to May and too much rain in the monsoon period (June to August) with the danger of erosion and collapse of the terraces

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



Annual crops: rice, potatoes, wheat

Humid subtropical

Water erosion: gullying, loss of topsoil and mass movement

Structural: level bench terraces

Vegetative: fodder grass on risers

Agronomic: green/farmyard manure, inorganic fertilisers

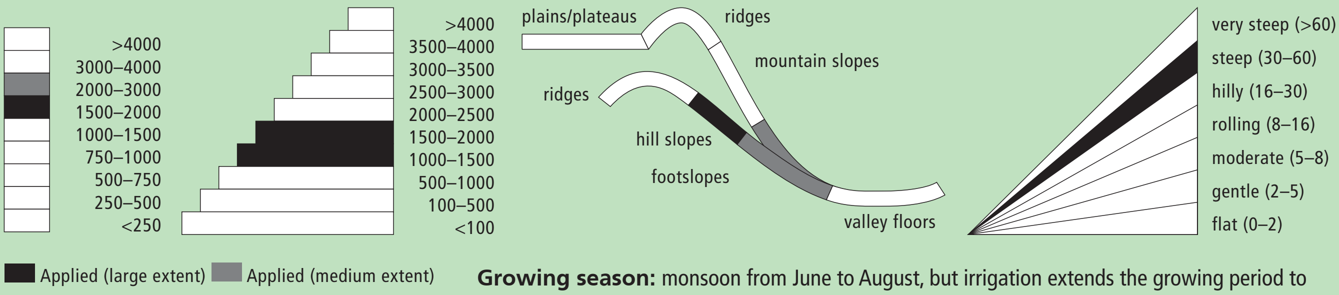
Technical function/impact

Main:
- control of dispersed and concentrated runoff
- reduction of slope angle and length
- increase and maintenance of water stored in soil
- increases soil fertility

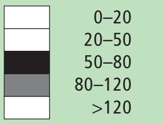
Secondary:
- water harvesting
- water spreading
- improves ground cover

Environment

Natural environment



Soil depth (cm)

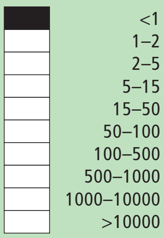


NB: Soil properties before SWC

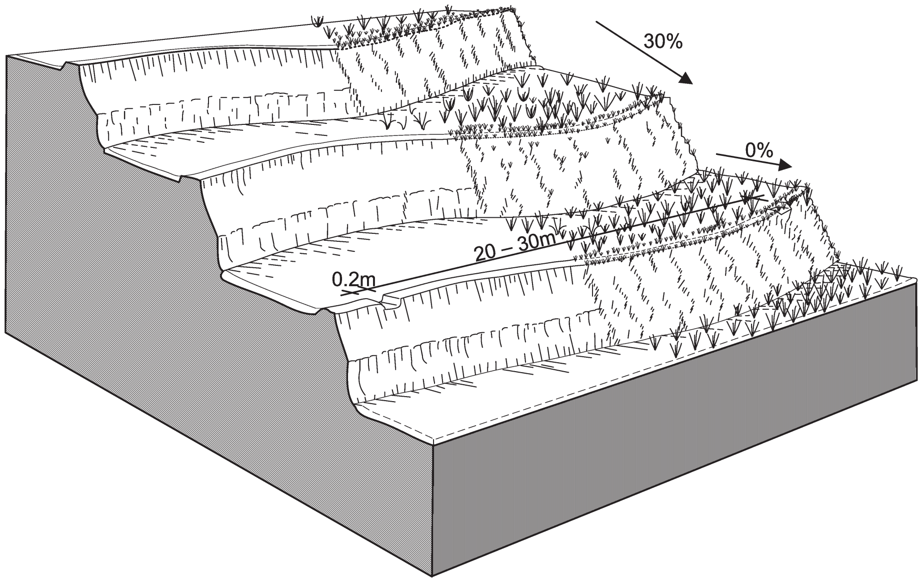
Growing season: monsoon from June to August, but irrigation extends the growing period to around 330 days (allowing 2-3 crops per year)
Soil fertility: medium
Soil texture: mainly medium (loam), partly coarse (sandy loam)
Surface stoniness: no loose stones
Topsoil organic matter: medium (1-3%)
Soil drainage: good because of the geology and soil texture (loam)
Soil erodibility: mainly high, partly medium

Human environment

Cropland per household (ha)



Land use rights: leased (90% of farmers), individual (10%)
Land ownership: individual, not titled
Market orientation: mixed: subsistence (rice/wheat) and commercial (potatoes)
Level of technical knowledge required: field staff/extension worker: high, land user: high
Number of livestock: not relevant
Importance of off-farm income: 10-50% of all income: hired labour (on other farmers' fields) or as porters



Technical drawing
Layout of irrigated terraces
Openings in the lips drain excess water, grass cover stabilises lips and risers (right).
After harvesting of rice, the grass is scraped off the lower part of the risers (left) and spread on the terrace beds

Implementation activities, inputs and costs

Establishment activities

1. Construct bunds (risers) with soil from upper and lower sides (soil transported in jute bags)
2. Level terrace beds (soil moved from upper to lower part of terraces)
3. Make lips on edges of terraces
4. Compact risers
5. Construct irrigation canal
6. Make openings in lips for drainage of excess water
7. Test-irrigate terrace for accurate levelling
8. Plant grasses including Bermuda grass *(Cynodon dactylon)*
9. After 2-3 years, some narrow terraces may be merged to form single, wider terraces

All activities are done by hand, with 1-6 done before and 7-8 during the monsoon

Duration of establishment phase: not specified

Establishment inputs and costs per ha

Inputs	Costs (US$)[1]	% met by land user
See remarks below		

Maintenance/recurrent activities

1. Harvest potato/wheat (January-March)
2. Transport cattle manure in a doko (basket carried on the back) to the field and leave it in heaps (March)
3. Spread the cattle manure (normally April)
4. Prepare land (plough/break compacted soil) for rice (April)
5. Flood the paddy fields (June/July), repeated 3-4 times during cultivation
6. Slice/scrape grass and soil on lower part of risers and spread on terraces (when flooded in June/July)
7. Plant rice and apply mineral fertiliser (June/July)
8. Harvest rice (October)
9. Apply manure (cattle manure) after rice harvest (October)
10. Slice/scrape grass and soil from whole of risers and spread on terraces (October/November)
11. Repair small collapses/slumps in risers (Oct/Nov)
12. Prepare land (November)
13. Plant potatoes and wheat (November)
14. Apply of mineral fertiliser (November/December)
15. Irrigate (November - repeated several times during cultivation)

All activities are done by hand except land preparation, which is sometimes done with small tractors or power tillers

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

Inputs	Cost (US$)[1]	% met by land user
Labour (125 person days)	350	100%
Equipment		
- Tools: hoe, spade, baskets - (doko)	5	100%
Agricultural		
- Fertiliser (650 kg)	185	100%
- Compost/manure (30 tonnes incl. transport)	300	100%
TOTAL	**840**	**100%**

[1] Exchange rate US$1 = NRs 77 in 2003

Remarks: Current establishment costs are very difficult to determine since the majority of the traditional terraces were established a long time ago. Costs depend closely on the present state of the land (forward sloping terraces or uncultivated) and the need for irrigation canals. Farmers say that construction now could cost up to US$ 10,000 per ha if carried out by hand at full labour cost. The cost given for maintaining the terraces (approx. US$ 840 per ha) includes all associated annual crop production costs. In this case study, 100% of construction costs were borne by the land users.

Assessment

Acceptance/adoption

- All the land users in the case study area who applied the technology did so without any outside incentives. In a nearby area, 50% of costs were met by the Bagmati Integrated Watershed Management Programme when converting existing rainfed forward-sloping terraces into level terraces which can be irrigated
- Maintenance has been continuously good over many generations
- Main motivation: irrigation guarantees high returns from small areas

Benefits/costs according to land users

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

Impacts of the technology*

Production and socioeconomic benefits

+++	Increased crop yield
+++	Increased farm income
+++	Increased livestock fodder
++	Increased quantity and quality of fodder

Production and socioeconomic disadvantages

- - -	Labour constraints as high labour inputs are needed
- -	More inputs required for better production in the initial stages
- -	Loss of land due to terrace risers

Socio-cultural benefits

+++	Improved knowledge of SWC/erosion
++	Strengthened community institution

Socio-cultural disadvantages

-	Socio-cultural conflicts may arise when agreed and scheduled water extraction amounts are exceeded
-	As part of a complex farming system, the technology is vulnerable to changes in norms and traditions (attraction influence of the nearby city for employment takes labour away)

Ecological benefits

+++	Increased soil moisture
+++	More efficient drainage of excess water
+++	Increased soil fertility
+++	Reduced soil loss
++	Enhanced biodiversity
++	Improved soil cover

Ecological disadvantages

-	Crabs in irrigation water make holes in the terrace risers, which in turn can cause pipe erosion and riser collapse

Off-site benefit

+++	Reduced downstream flooding
+++	Reduced downstream siltation
+++	Increased groundwater recharge
+++	Increased soil moisture and nutrients downstream
++	Reduced river pollution

Off-site disadvantages

- -	Reduced river flows during dry season as river water is used upstream for terrace irrigation
-	Poor maintenance of topmost terraces may cause landslides

In this case: impacts of traditional paddy rice terraces in comparison to forward-sloping rainfed terraces

* 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
Income and production increased ➔Proper management of the terraces (including all maintenance activities)	Decreased grass production (grazing area reduced) ➔Promote planting of high value grass species on risers (such as Bermuda grass)
Easier to cultivate flat terraces/less labour required (after establishment of terraces)	The farmers believe that the terraces are too narrow (for efficient use of tractors); they would like to have wider terraces ➔Investigate possibilities of constructing wider paddy rice terraces on steep slopes, which, according to present experience, is not possible
Work sharing: traditional terraces are part of a long tradition of work sharing within the community with no external labour needed ➔Prevent loss of well established traditions and norms	High labour costs for establishment
Technology is easy to understand/apply	
The irrigation element of this technology fosters social bonds within the community ➔Prevent loss of well established norms and traditions	
Increased opportunities for irrigation facilities: farmers without level terraces are not allowed (by the irrigation committee at village level) or do not claim irrigation water	

Key reference(s): There is considerable literature on the construction and maintenance of irrigated terraces in general, but no references that refer directly to traditional paddy rice terraces in Nepal

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