Consolidated Terraces (Irrigated Paddy Fields) (Sonam Wangchuk)

Terrace Consolidation by Machine (Bhutan)

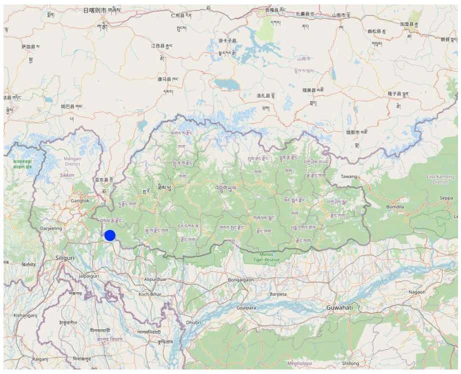
Thruel Chhey Lag Len Thap Tey Aring Ja Kaed Tang Ni (ཕྲུལ་ཆས་ཐོག་ཨ་རིང་བརྒྱ་སྐྱེད་བཏང་ནི།)

DESCRIPTION

Terrace consolidation is the merging of existing narrow bench terraces into larger terraces to enable farm mechanization, commercial farming and crop intensification. This technology is promoted as the existing terraces are generally narrow and this limits efficient operation and utilization of land and other resources.

Terrace consolidation involves merging of small terraces into larger terraces using a machine to make more efficient use of land through farm mechanization, commercial farming and crop intensification. This technology is promoted as the existing terraces are generally narrow and this limits efficient operation and utilization of land and other resources.
The consolidation of narrow terraces is recommended if the general slope of the proposed site is less than 20° (36%) with good soil drainage and low risk of land degradation. While consolidating narrow terraces, it is strongly recommended to remove the topsoil from the terraces and put it back once the levelling is completed. The consolidated terrace should maintain a maximum riser height of 1.5 m and bed width of 3.5 m. For slopes below 12° (21%), the bench width should not exceed 5–6 m.
Farmers can expand the amount of arable land available, maximize agricultural operations, and encourage sustainable farming methods for higher crop output and enhanced ecological resilience by converting narrower and more steep bench terraces into bigger ones (NSSC, 2020). A large portion of hillside farmers around the world rely on terracing. For the purpose of facilitating the growth of field crops, horticultural crops, fodder, and other crops that require specific management practices (e.g., irrigation), alone or in agroforestry systems, hilly or mountainous terrains are divided into narrow but graduated steps, typically 2-3 m wide and 50-80 m long across the slopes (Chapagain & Raizada, 2017).
Enlargement of terraces begins with a thorough survey and analysis of the topography and terrain. In order to build larger terraces with the least amount of environmental damage, this phase is essential. The next step in the construction process is to reshape the present, small terraces into larger, more open ones. To make wider terraced levels, this may entail moving soil and cutting through slopes. Furthermore, filling up the gaps and levelling the land's surface is required in order to reduce the number of risers and produce a continuous, gently sloping terrace. The installation of suitable drainage systems is also crucial to guarantee adequate water management and stop soil erosion.
Larger terraces enhance water management capabilities. With a more extensive surface area, water runoff is minimized, and the distribution of irrigation water becomes more even, promoting better soil moisture retention and reducing erosion. This, in turn, contributes to soil health and fertility, supporting sustainable farming practices. Moreover, the consolidation of smaller terraces into larger ones reduces the overall number of risers, thereby enhancing accessibility for farmworkers and farm machinery. This ease of access further optimizes the use of resources and fosters better crop management. Additionally, larger terraces can enable the implementation of crop diversification strategies, such as intercropping and crop rotation, promoting biodiversity and mitigating the risk of crop failure due to pests or adverse weather conditions.
However, the process of enlarging terraces involves altering the terrain, which can lead to soil erosion, habitat destruction, and ecological imbalances. This environmental impact may negatively affect local flora and fauna, reducing biodiversity and disrupting the delicate ecological equilibrium (Deng et al., 2021). Planning for safe discharge of excess water out of the terrace system effectively helps preserve soil fertility and reduces runoff. It is essential also to pay close attention to the preservation of the local ecosystem and biodiversity throughout the process.

LOCATION



Location: Sang-Ngag-Chhoeling, Samtse, Bhutan

No. of Technology sites analysed: 2-10 sites

Geo-reference of selected sites
- 88.97161, 26.95436

Spread of the Technology: evenly spread over an area (approx. < 0.1 km2 (10 ha))

In a permanently protected area?: Nee

Date of implementation: 2021

Type of introduction
- [ ] through land users' innovation
- [ ] as part of a traditional system (> 50 years)
- [ ] during experiments/ research
- [x] through projects/ external interventions

Terrace Consolidation in Progress using an excavator (Tashi Wangdi)

Consolidated Terraces (Sonam Wangchuk)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

- ☑ improve production
- ☑ reduce, prevent, restore land degradation
- ☐ conserve ecosystem
- ☐ protect a watershed/ downstream areas – in combination with other Technologies
- ☐ preserve/ improve biodiversity
- ☐ reduce risk of disasters
- ☑ adapt to climate change/ extremes and its impacts
- ☑ mitigate climate change and its impacts
- ☑ create beneficial economic impact
- ☐ create beneficial social impact

Land use

Land use mixed within the same land unit: Nee

CroplandNumber of growing seasons per year: 1
Is intercropping practiced? Nee
Is crop rotation practiced? Nee

Water supply

- ☐ rainfed
- ☑ mixed rainfed-irrigated
- ☐ full irrigation

Purpose related to land degradation

- ☐ prevent land degradation
- ☑ reduce land degradation
- ☐ restore/ rehabilitate severely degraded land
- ☑ adapt to land degradation
- ☐ not applicable

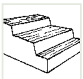
Degradation addressed

soil erosion by water - Wt: loss of topsoil/ surface erosion, Wg: gully erosion/ gullying

SLM group

- cross-slope measure
- wetland protection/ management
- ecosystem-based disaster risk reduction

SLM measures

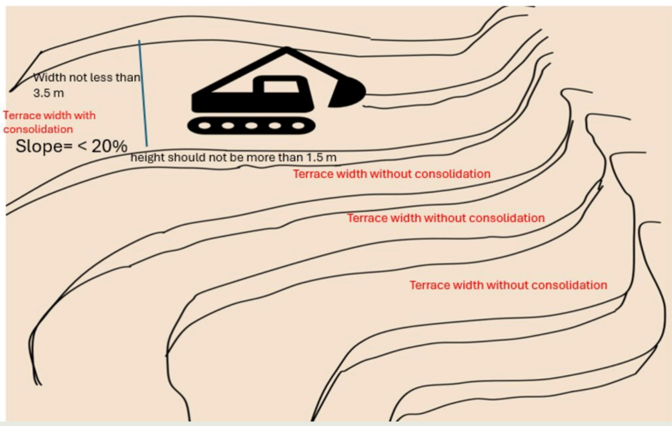


structural measures - S1: Terraces, S2: Bunds, banks

TECHNICAL DRAWING

Technical specifications

consolidation of old and small terraces with machines



Author: karma Wangdi

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs
- Costs are calculated: per Technology area (size and area unit: **2.5 acre**; conversion factor to one hectare: **1 ha = 1ha**)
- Currency used for cost calculation: **Ngultrum**
- Exchange rate (to USD): 1 USD = 80.0 Ngultrum
- Average wage cost of hired labour per day: 500

Most important factors affecting the costs
The major factor affecting the cost for implementing this technology is in hiring of excavator

Establishment activities
1. Secure funding support from GCF (Timing/ frequency: January (Before cropping))
2. Action planning in consultation with beneficiaries and the stakeholders (Timing/ frequency: February (Before cropping))
3. Arrangement of excavator machine (Timing/ frequency: First week of March (Before cropping))
4. Activity implementation (Timing/ frequency: Second week of March till April (Before cropping))

Establishment inputs and costs (per 2.5 acre)

Specify input	Unit	Quantity	Costs per Unit (Ngultrum)	Total costs per input (Ngultrum)	% of costs borne by land users
Labour					
Assisting operator (reaching fuel)	no	60.0	500.0	30000.0	100.0
Labelling of terraces	no	60.0	500.0	30000.0	100.0
Equipment					
Hiring of Excavator	day	6.0	20000.0	120000.0	
Total costs for establishment of the Technology				**180'000.0**	
Total costs for establishment of the Technology in USD				*2'250.0*	

Maintenance activities
n.a.

NATURAL ENVIRONMENT

Average annual rainfall
- [ ] < 250 mm
- [ ] 251-500 mm
- [ ] 501-750 mm
- [ ] 751-1,000 mm
- [ ] 1,001-1,500 mm
- [x] 1,501-2,000 mm
- [ ] 2,001-3,000 mm
- [x] 3,001-4,000 mm
- [ ] > 4,000 mm

Agro-climatic zone
- [ ] humid
- [x] sub-humid
- [ ] semi-arid
- [ ] arid

Specifications on climate
Average annual rainfall in mm: 1500.0
The gewog experiences mostly heavy shower with annual rainfall ranging from 1500 mm to 4000 mm
Name of the meteorological station: National Center for Hydrology and Metrology (NCHM), Bhutan
Subtropical monsoon climatic zone

Slope
- [ ] flat (0-2%)
- [x] gentle (3-5%)
- [ ] moderate (6-10%)
- [ ] rolling (11-15%)
- [ ] hilly (16-30%)
- [ ] steep (31-60%)
- [ ] very steep (>60%)

Landforms
- [ ] plateau/plains
- [x] ridges
- [ ] mountain slopes
- [ ] hill slopes
- [ ] footslopes
- [ ] valley floors

Altitude
- [ ] 0-100 m a.s.l.
- [ ] 101-500 m a.s.l.
- [x] 501-1,000 m a.s.l.
- [ ] 1,001-1,500 m a.s.l.
- [ ] 1,501-2,000 m a.s.l.
- [ ] 2,001-2,500 m a.s.l.
- [ ] 2,501-3,000 m a.s.l.
- [ ] 3,001-4,000 m a.s.l.
- [ ] > 4,000 m a.s.l.

Technology is applied in
- [ ] convex situations
- [ ] concave situations
- [x] not relevant

Soil depth
- [ ] very shallow (0-20 cm)
- [x] shallow (21-50 cm)
- [ ] moderately deep (51-80 cm)
- [ ] deep (81-120 cm)
- [ ] very deep (> 120 cm)

Soil texture (topsoil)
- [ ] coarse/ light (sandy)
- [ ] medium (loamy, silty)
- [ ] fine/ heavy (clay)

Soil texture (> 20 cm below surface)
- [ ] coarse/ light (sandy)
- [ ] medium (loamy, silty)
- [ ] fine/ heavy (clay)

Topsoil organic matter content
- [ ] high (>3%)
- [ ] medium (1-3%)
- [ ] low (<1%)

Groundwater table
- [ ] on surface
- [ ] < 5 m
- [ ] 5-50 m
- [ ] > 50 m

Availability of surface water
- [ ] excess
- [x] good
- [ ] medium
- [ ] poor/ none

Water quality (untreated)
- [x] good drinking water
- [ ] poor drinking water (treatment required)
- [ ] for agricultural use only (irrigation)
- [ ] unusable

Water quality refers to:

Is salinity a problem?
- [ ] Ja
- [x] Nee

Occurrence of flooding
- [x] Ja
- [ ] Nee

Species diversity
- [ ] high
- [x] medium
- [ ] low

Habitat diversity
- [ ] high
- [x] medium
- [ ] low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
- [ ] subsistence (self-supply)
- [x] mixed (subsistence/ commercial)
- [ ] commercial/ market

Off-farm income
- [x] less than 10% of all income
- [ ] 10-50% of all income
- [ ] > 50% of all income

Relative level of wealth
- [ ] very poor
- [ ] poor
- [x] average
- [ ] rich
- [ ] very rich

Level of mechanization
- [x] manual work
- [x] animal traction
- [ ] mechanized/ motorized

Sedentary or nomadic
- [x] Sedentary
- [ ] Semi-nomadic
- [ ] Nomadic

Individuals or groups
- [x] individual/ household
- [ ] groups/ community
- [ ] cooperative
- [ ] employee (company, government)

Gender
- [x] women
- [x] men

Age
- [x] children
- [x] youth
- [x] middle-aged
- [x] elderly

Area used per household
- [ ] < 0.5 ha
- [ ] 0.5-1 ha
- [x] 1-2 ha
- [ ] 2-5 ha
- [ ] 5-15 ha
- [ ] 15-50 ha
- [ ] 50-100 ha
- [ ] 100-500 ha
- [ ] 500-1,000 ha
- [ ] 1,000-10,000 ha
- [ ] > 10,000 ha

Scale
- [ ] small-scale
- [x] medium-scale
- [ ] large-scale

Land ownership
- [ ] state
- [ ] company
- [ ] communal/ village
- [ ] group
- [ ] individual, not titled
- [ ] individual, titled
- [x] Family

Land use rights
- [ ] open access (unorganized)
- [x] communal (organized)
- [ ] leased
- [x] individual

Water use rights
- [ ] open access (unorganized)
- [x] communal (organized)
- [ ] leased
- [x] individual

Access to services and infrastructure

health	poor		✓ (middle)	good
education	poor		✓ (middle)	good
technical assistance	poor		✓ (middle)	good
employment (e.g. off-farm)	poor	✓ (poor)		good
markets	poor		✓ (middle)	good
energy	poor		✓ (middle)	good
roads and transport	poor		✓ (middle)	good
drinking water and sanitation	poor		✓ (good)	good
financial services	poor		✓ (middle)	good

IMPACTS

Socio-economic impacts

Crop production

decreased ✓ (7th of 7 boxes) increased

Before the terrace consolidation they used to have minimum production but now they are producing for both self consumption and commercial purpose. these are expert estimates or data measured.

production area (new land under cultivation/ use)

decreased ✓ (7th of 7 boxes) increased

The merging of small terraces has increased the cropping area. These are expert estimates or data measured.

land management

hindered ✓ (7th of 7 boxes) simplified

Overall Land management has become easier for them as they can use more machines due to larger flat terraces

expenses on agricultural inputs

increased ✓ (7th of 7 boxes) decreased

The deployment of number of labor has reduced with the intervention of farm machineries, thus reducing the cost of production with reduced time and man power. These are expert estimates or data measured.

farm income

decreased ✓ (7th of 7 boxes) increased

Farm income has increased compared to past as they have larger area of cultivation.

diversity of income sources

decreased ✓ (7th of 7 boxes) increased

The time and resources saved from this technology intervention has been beneficial in for other use. These are expert estimates or data measured.

workload

increased ✓ (7th of 7 boxes) decreased

Due to mechanized farming favoured by terrace consolidation, the workload at an individual level has significantly reduced. These are expert estimates or data measured.

Socio-cultural impacts

food security/ self-sufficiency

The increased cropping area and contributed in increase in

	reduced / improved		production, thus enhancing the food and nutrition security. These are expert estimates or data measured.
health situation	worsened / improved	✓ (improved)	The better crop productivity is found to be contributing better health quality of the farm household. These are expert estimates or data measured.
SLM/ land degradation knowledge	reduced / improved	✓ (improved)	Could have better understanding on SLM and its benefits through the sensitization programs. These are expert estimates or data measured.

Ecological impacts

soil loss	increased / decreased	✓ (decreased)	The flat terraces has been always been adventitious in controlling overall soil and nutrient loss. These are expert estimates or data measured.
soil accumulation	decreased / increased	✓ (increased)	Because of very minimum soil loss, the soil accumulation rate in these terraces has been very high. These are expert estimates or data measured.

Off-site impacts

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative / very positive	✓ (positive)
Long-term returns	very negative / very positive	✓ (positive)

Benefits compared with maintenance costs

Short-term returns	very negative / very positive	✓ (positive)
Long-term returns	very negative / very positive	✓ (positive)

CLIMATE CHANGE

Gradual climate change

annual temperature increase	not well at all / very well	✓ (very well)	
annual rainfall decrease	not well at all / very well		Answer: not known

Climate-related extremes (disasters)

local rainstorm	not well at all / very well	✓ (well)
local thunderstorm	not well at all / very well	✓ (well)
local windstorm	not well at all / very well	✓ (well)
heatwave	not well at all / very well	✓ (well)
cold wave	not well at all / very well	✓ (well)
extreme winter conditions	not well at all / very well	✓ (well)
drought	not well at all / very well	✓ (not well)

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

- [ ] single cases/ experimental
- [x] 1-10%
- [ ] 11-50%
- [ ] > 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

- [x] 0-10%
- [ ] 11-50%
- [ ] 51-90%
- [ ] 91-100%

Number of households and/ or area covered

8 households

Has the Technology been modified recently to adapt to changing conditions?

- [ ] Ja
- [x] Nee

To which changing conditions?

- [ ] climatic change/ extremes
- [ ] changing markets
- [ ] labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Increased production

Weaknesses/ disadvantages/ risks: land user's viewhow to overcome

- Enhanced farm mechanization and workability

Strengths: compiler's or other key resource person's view
- Reduced surface runoff
- Optimal use of resources
- Increased production
- Enhanced farm mechanization and workability

- cost for terrace consolidation help and support through government and projects

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's viewhow to overcome
- Heavy and large machineries (excavator) used to carry out terrace consolidation might pose soil compaction and sealing Use of smaller excavators specifically designed for terracing

REFERENCES

Compiler
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Reviewer
William Critchley
Rima Mekdaschi Studer
Joana Eichenberger

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Resource persons
Ram Bahadur Limbu - land user

Full description in the WOCAT database
https://qcat.wocat.net/af/wocat/technologies/view/technologies_6871/

Linked SLM data
n.a.

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