Stone Check Wall in Nakina Village (Hanspeter Liniger)

Stone Check Walls and Check Dams for Soil and Water Conservation (India)

DESCRIPTION

Stone Check Dams/Walls, Retainment Walls, and a Water Diversion Wall has been constructed in Nakina Village and Nakina Community Forest to help protect their settlements, agriculture land, forest land, and preserve the hilly landscape. These structures serve to reduce the runoff velocity (lowering the rate of erosion and gullying in steep slope channels) and increase infiltration for groundwater recharge.

1. The technology is found in both natural and human environments (forest and settlement areas)

2. Main Characteristics: A check dam or check wall is constructed in a loose or active gully or a rill (shallow channel) that threatens to enlarge, or anywhere on a slope where there is a danger of scour from running water. The structures lower the velocity of flow. In Nakina porous check walls, check dams, and retainment walls were made out of stone gathered from the surrounding area. A porous check dam releases a portion of flow through the structure, decreases the head of flow over the spillway, and decreases the dynamic and hydrostatic forces against the check dam. Porous check dams are simple and more economical for construction.

Once stones are collected they are cut into suitable sizes and surfaces ("dressing" of stones). The site where the technology is to be constructed is then cleared and, for check dams, the sides are sloped 1:1 (this simply refers to the ratio of the rise and run of the slope, so 1:1 means you'll have a 45 degree slope for your excavation). This is also known as the angle of repose, where the granular material of the embankment will be stable and not slump from its own weight. The base of the dam should be around 70 cm thick if it is 1 meter high. The bed of gully is excavated for foundation and dry stones are packed from that level.

3. Purposes/functions: Interrupts the flow of water and flattens the gradient of a channel, thereby reducing the velocity and inducing infiltration rather than eroding the channel. These structures not only slow flow velocity but also to distribute flows across vegetation. Despite some sedimentation resulting behind the dam, small cracks and porous spaces in the holes of the stones allow some sediment to flow through and the finer particles fill the gaps and strengthen the structure. Check dams can also be designed to create small reservoirs.

4. Major activities include identifying the appropriate site of installation, collection of construction materials, technical planning of the structure dimensions and design, manual labor, and maintenance.

5. Benefits/impacts: These structures decelerate runoff and accelerates groundwater recharging by storing water and facilitating infiltration of water into the soil

6. Like/Dislike:
Advantages
•Inexpensive and relatively easy to install given local building materials and labor availability
•Reduce velocity, prevent gully erosion and cause a high proportion of the sediment load in runoff to settle out, preventing downstream damage
•When carefully located and designed, check dams can remain as permanent installations with very minor regrading

Disadvantages
•Many of these structures have a temporary nature, and need to reconstructed or removed after significant damage
•Removal or reconstruction may be a significant cost depending on the size and design
•May kill grass linings in channels if the water level remains high after rainstorms or if there is significant sedimentation.
•May create turbulence which erodes the channel banks.
•Clogging by organic material may be a problem and hinder the structure's function

LOCATION

Location: Nakina Village, Pithoragarh Bloc, Uttarakhand, India

No. of Technology sites analysed: 2-10 sites

Geo-reference of selected sites
- 80.17232, 29.62836
- 80.17278, 29.62889
- 80.17259, 29.62861
- 80.17299, 29.62902
- 80.17326, 29.6291
- 80.17538, 29.62405
- 80.17561, 29.62427
- 80.17073, 29.62678
- 80.17634, 29.62495
- 80.176, 29.62471
- 80.1758, 29.62448

Spread of the Technology: applied at specific points/ concentrated on a small area

In a permanently protected area?: Yes

Date of implementation: more than 50 years ago (traditional)

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


Check Dam reservoir in Nakina Community Forest (Jaclyn Bandy)


Check wall in Nakina Village (Jaclyn Bandy)

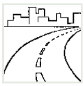
CLASSIFICATION OF THE TECHNOLOGY

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

Land use


Forest/ woodlands
- (Semi-)natural forests/ woodlands: subtropical dry forest natural vegetation. Management: Selective felling

Tree types (deciduous): n.a.
Products and services: Timber, Fuelwood, Grazing/ browsing, Nature conservation/ protection



Settlements, infrastructure - Settlements, buildings

Water supply
- [x] rainfed
- [ ] mixed rainfed-irrigated
- [ ] full irrigation

Purpose related to land degradation
- [x] prevent land degradation
- [x] reduce land degradation
- [ ] restore/ rehabilitate severely degraded land
- [ ] adapt to land degradation
- [ ] not applicable

Degradation addressed

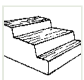

soil erosion by water - Wt: loss of topsoil/ surface erosion, Wg: gully erosion/ gullying, Wm: mass movements/ landslides, Wr: riverbank erosion, Wo: offsite degradation effects

physical soil deterioration - Ps: subsidence of organic soils, settling of soil

biological degradation - Bc: reduction of vegetation cover, Bq: quantity/ biomass decline

water degradation - Hg: change in groundwater/aquifer level

SLM group
- cross-slope measure
- water diversion and drainage
- surface water management (spring, river, lakes, sea)

SLM measures


structural measures - S3: Graded ditches, channels, waterways, S6: Walls, barriers, palisades, fences

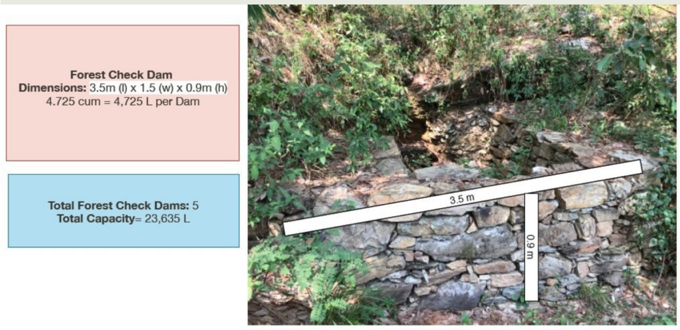
TECHNICAL DRAWING

Technical specifications

None

Author: Jaclyn Bandy

None



Author: Jaclyn Bandy

None

Author: Jaclyn Bandy

None

Author: Jaclyn Bandy

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology unit (unit: **1. Small Check Dams 2. Large Check Walls 3. Water Diversion Wall 4. Bhind Check Walls/Retainment wall** volume, length: **1. 5 units (3.5m**

Most important factors affecting the costs

Size of the check dam/check wall Frequency and intensity of the damage to the structures Labor availability

x 1.5m x 0.9m) 2. 5 units (8m x 1m x 2.7m) 3. 1 unit (115m x 0.65 x 0.95m) 4. 1 unit (100m x 1m x 1.5m)**)
- Currency used for cost calculation: **INR**
- Exchange rate (to USD): 1 USD = 70.0 INR
- Average wage cost of hired labour per day: 400 INR per head/day

Establishment activities

1. Nakina village built a long water diversion wall over +50 years ago that serves as a water channel, directing runoff away from settlements and towards the ravine (Timing/ frequency: Pre-monsoon /dry season)
2. Within the ravine/gully in Nakina Village, there is a series of 5 large check walls that were established with the help of the Forest Department (Timing/ frequency: Pre-monsoon /dry season)
3. There is a series of check walls/check dams in another gully that were established in 1952 above the Bhind Spring/Naula (on the opposite side of the village) to protect it and decrease runoff/further erosion (Timing/ frequency: Pre-monsoon/dry season)
4. In December 2017 the Nakina Van Panchayat (community forest council) decided to construct 5 new check dams within the Nakina Forest, which lie in the upper catchment area of the Bhind Spring (Timing/ frequency: Pre-monsoon/dry season)
5. For the establishment of all these structures, the community and technical assistants assessed the topography of the area, size of the gully, catchment area and runoff rate before establishing the check-dam. (Timing/ frequency: Pre-monsoon/dry season)
6. The sites were selected and prepared by removing debris and other unsuitable material which would interfere with proper placement of the check dam/wall materials. (Timing/ frequency: Pre-monsoon/dry season)

Establishment inputs and costs (per 1. Small Check Dams 2. Large Check Walls 3. Water Diversion Wall 4. Bhind Check Walls/Retainment wall)

Specify input	Unit	Quantity	Costs per Unit (INR)	Total costs per input (INR)	% of costs borne by land users
Labour					
Large Water Diversion Wall	person-days	60.0	400.0	24000.0	20.0
5 Large Check Walls	person-days	50.0	400.0	20000.0	20.0
Bhind Spring Check Walls/Retainment Wall	person-days	19.0	400.0	7600.0	50.0
5 Small Check Walls in Forest	person-days	10.0	400.0	4000.0	100.0
Equipment					
Crate Wire (15m x 2m x 2m)	Cum	60.0	75.0	4500.0	
Pick	pieces	15.0	300.0	4500.0	100.0
Shovel	pieces	20.0	500.0	10000.0	100.0
pharuwa (hoe)	pieces	15.0	300.0	4500.0	100.0
khanti (digging bar)	pieces	10.0	1500.0	15000.0	100.0
hammer (5kg)	pieces	10.0	2000.0	20000.0	100.0
chino (chisel)	pieces	10.0	500.0	5000.0	100.0
khukuri (knife)	pieces	10.0	250.0	2500.0	100.0
Plant material					
small hammer (0.5-1 kg)	pieces	15.0	300.0	4500.0	100.0
Construction material					
Rocks of various size and shape collected/excavated on site					
Small Check Walls in Forest (5)	cum	23.625	200.0	4725.0	100.0
Large Check Walls (5)	cum	108.0	200.0	21600.0	20.0
Large Water Diversion Wall (1)	cum	71.0	200.0	14200.0	100.0
Bhind Check Walls/Retainment Wall (5)	cum	150.0	200.0	30000.0	50.0
Other					
Rocks of various size and shape collected/excavated on site					
Total costs for establishment of the Technology				**196'625.0**	
Total costs for establishment of the Technology in USD				*2'808.93*	

Maintenance activities

1. Inspection of the check dam for rock displacement and erosion around the ends of the dam after each significant rainfall event (Timing/ frequency: Monsoon/ weekly)
2. Sediment accumulation is removed if it reaches a depth of ½ the original dam height (Timing/ frequency: Pre-monsoon/Monsoon)
3. Sometimes check dams are removed when their useful life is completed (Timing/ frequency: Annual inspections)

Maintenance inputs and costs (per 1. Small Check Dams 2. Large Check Walls 3. Water Diversion Wall 4. Bhind Check Walls/Retainment wall)

Specify input	Unit	Quantity	Costs per Unit (INR)	Total costs per input (INR)	% of costs borne by land users
Labour					
Reconstruction of damaged check dams	person-days/unit	10.0	400.0	4000.0	100.0
Removal of sediment	person-days/unit	5.0	400.0	2000.0	100.0
Equipment					

pick	pieces	3.0	70.0	210.0	100.0
shovel	pieces	3.0	42.0	126.0	100.0
pharuwa (hoe)	pieces	2.0	52.0	104.0	100.0
khanti (digging bar)	pieces	2.0	30.0	60.0	100.0
hammer	pieces	3.0	25.0	75.0	100.0
chino (chisel)	pieces	2.0	75.0	150.0	100.0
khukuri (knife)	pieces	2.0	22.0	44.0	100.0
small hammer (0.5-1kg)	pieces	3.0	120.0	360.0	100.0
Construction material					
Stones available at site locally					
Total costs for maintenance of the Technology				**7'129.0**	
Total costs for maintenance of the Technology in USD				*101.84*	

NATURAL ENVIRONMENT

Average annual rainfall
- [ ] < 250 mm
- [ ] 251-500 mm
- [ ] 501-750 mm
- [ ] 751-1,000 mm
- [x] 1,001-1,500 mm
- [x] 1,501-2,000 mm
- [ ] 2,001-3,000 mm
- [ ] 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
Monsoon- mid-June to mid-September; July and August are the rainiest months and the temperature is warm and moist; between 70-85% of the annual precipitation occurs in the monsoon season

Seasons
a. Winter or Cold weather (mid Dec. - mid March)
b. Summer or hot weather (mid March - mid June)
c. Season of general rains (South - West monsoon season)
d. Season of retreating monsoon (mid September to mid November)
Name of the meteorological station: India Meteorological Department, Meteorological Centre Dehradun
The overall climatic condition in the Pithoragarh district is governed by the southwest monsoon. It has a sub-tropical to temperate climate, with three pronounced seasons; summer, winter, and monsoon. The hilly terrain of the Himalayan region has snow cover and is cold during winter with snowfall normally occurring during the months of December to March.

Temperature- The temperature ranges from 0°C to 10°C in winter and from 8°C to 33°C in summer season. However, there is no meteorological observatory in the district. The account of the climate is based mainly on the records of the observations in the neighboring districts where similar meteorological conditions prevail. Variations in temperature are considerable from place to place and depend upon elevation as well as aspect. As the insolation is intense at high altitudes, in summer temperatures are considerably higher in the open than in the shade.

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

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

Altitude
- [ ] 0-100 m a.s.l.
- [ ] 101-500 m a.s.l.
- [ ] 501-1,000 m a.s.l.
- [x] 1,001-1,500 m a.s.l.
- [x] 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
- [x] concave situations
- [ ] not relevant

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

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

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

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

Availability of surface water
- [ ] excess
- [ ] good
- [x] 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: ground water

Is salinity a problem?
- [ ] Yes
- [x] No

Occurrence of flooding
- [ ] Yes
- [x] No

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

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

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

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

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

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

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

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

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

Gender
- [x] women
- [x] men

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

Area used per household
- [x] < 0.5 ha
- [x] 0.5-1 ha
- [ ] 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
- [x] small-scale
- [ ] medium-scale
- [ ] large-scale

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

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

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

Access to services and infrastructure

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

Comments
The situation of infrastructure is difficult and inconsistent in the hill regions because of the terrain. The major infrastructural issues are drinking water and irrigation facilities, electricity, transportation and communication facilities and social infrastructure (housing and education). As for financial services, only the State Bank of India (SBI) is active in the hill regions where it is trying to achieve the objective of 100% financial inclusion. Some villages mentioned buying into into agricultural insurance in the past, however this was a temporary enterprise and they were never compensated after extreme climatic events that occurred and damaged over 70% of their crop. Though infrastructure and education has generally improved over the years, institutional and marketing networks in the region aimed at supporting hill-farmers are lacking.

IMPACTS

Socio-economic impacts

	from							to	Comment
forest/ woodland quality	decreased						✓	increased	
land management	hindered						✓	simplified	The check dams helped deter the damage from runoff to their settlements and conserved the forest trail that is commonly used to access the areas where fodder/grass collection is permitted.

Socio-cultural impacts

	from							to	Comment
SLM/ land degradation knowledge	reduced						✓	improved	People have seen the benefits of constructing these structures, and they continue to participate in maintaining and building more check dams to reduce erosion and increase groundwater recharge.

Ecological impacts

	from							to
water quantity	decreased						✓	increased
harvesting/ collection of water (runoff, dew, snow, etc)	reduced						✓	improved
surface runoff	increased						✓	decreased
excess water drainage	reduced						✓	improved
groundwater table/ aquifer	lowered						✓	recharge
evaporation	increased						✓	decreased

soil moisture	decreased							✓	increased
soil cover	reduced							✓	improved
soil loss	increased							✓	decreased
soil accumulation	decreased							✓	increased
soil crusting/ sealing	increased							✓	reduced
soil compaction	increased							✓	reduced
nutrient cycling/ recharge	decreased							✓	increased
vegetation cover	decreased							✓	increased
biomass/ above ground C	decreased							✓	increased
landslides/ debris flows	increased							✓	decreased
drought impacts	increased							✓	decreased
impacts of cyclones, rain storms	increased							✓	decreased
fire risk	increased							✓	decreased
micro-climate	worsened							✓	improved

Off-site impacts

water availability (groundwater, springs)	decreased							✓	increased
reliable and stable stream flows in dry season (incl. low flows)	reduced							✓	increased
downstream siltation	increased							✓	decreased
buffering/ filtering capacity (by soil, vegetation, wetlands)	reduced							✓	improved
damage on neighbours' fields	increased							✓	reduced
damage on public/ private infrastructure	increased							✓	reduced

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative						✓		very positive
Long-term returns	very negative							✓	very positive

Benefits compared with maintenance costs

Short-term returns	very negative						✓		very positive
Long-term returns	very negative						✓		very positive

Although maintenance can be troublesome and require lots of manual labor for repair, the long term benefits and avoided damage from monsoon runoff outweigh the costs/effort.

CLIMATE CHANGE

Gradual climate change

annual temperature increase	not well at all				✓		very well
Irregular rainfall increase	not well at all				✓		very well

Climate-related extremes (disasters)

local rainstorm	not well at all				✓		very well
drought	not well at all				✓		very well
forest fire	not well at all				✓		very well
flash flood	not well at all				✓		very well
landslide	not well at all			✓			very well

ADOPTION AND ADAPTATION

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

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

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

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

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

- [ ] Yes
- [x] No

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

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

- Decrease velocity of runoff and erosive processes to the landscape
- Support recharge of groundwater/springshed recharge
- Increase water availability for surrounding vegetation
- Well constructed check dams function as permanent installations and require little maintenance
- The technology is relatively inexpensive and easy to install

Strengths: compiler's or other key resource person's view
- Views aligned with the land-user
- There is potential for the village to construct more check dams and use the water for storage/irrigation purposes

- Removal and reconstruction can be costly for some types of check dams Give thorough attention to the criteria for the site selection to avoid the need for removal; stress the need for maintenance and structure check ups.
- There can be turbulence downstream, causing erosion of the channel banks. Vegetative interventions can support these structures, so trees or shrubs can be planted around and in the spaces between check dams to further decrease runoff velocity, increase infiltration, and act as a shock absorber.

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's viewhow to overcome
- Aligned with the land user The government should consider providing appropriate incentives for constructing and managing check-dams, which enable more efficient use of water and also generate the positive externality of recharging ground water in surrounding areas.
- Check dam construction, if not done by skilled labour, can fail. These situations often arise and become noticeable to the land users when check-dams located upstream are damaged and there is a rapid flow of water to check-dams located downstream. Special maintenance can be performed by designated people to monitor the status of check dams upstream
- The large check dams have consistent issues and appear to require more reconstruction. These structures are located downstream and must bear more pressure. The reason for their damage could be inconsistency in repairing existing damage before monsoon. Construction cost is then increased, as additional cost is incurred in removing the accumulated silt and arranging new boulders. The land users should organize themselves more formally for check dam reconstruction is this area. Collectively generating the necessary capital and labor needed for timely reconstruction may be required from external sources like the Forest Department or JICA organization.

REFERENCES

Compiler
Jaclyn Bandy

Editors

Reviewer
Hanspeter Liniger

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Resource persons
Joshi Jagdamba - land user

Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_5210/

Linked SLM data
Approaches: Community Forest Management in the Nakina Van Panchayat https://qcat.wocat.net/en/wocat/approaches/view/approaches_5199/
Approaches: Naula Management and Conservation https://qcat.wocat.net/en/wocat/approaches/view/approaches_5202/
Approaches: Community Forest Management in the Nakina Van Panchayat https://qcat.wocat.net/en/wocat/approaches/view/approaches_5199/
Approaches: Naula Management and Conservation https://qcat.wocat.net/en/wocat/approaches/view/approaches_5202/
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Project
- Onsite and Offsite Benefits of SLM

Key references

- Evaluation of the effect of porous check dam location on fine sediment retention (a case study), A. M. Hassanli, A. Esmaeli Nameghi, S. Beecham, 2007.: DOI 10.1007/s10661-008-0318-2

Links to relevant information which is available online
- Mainstreaming Slope Stability Management: http://www.research4cap.org/Library/ScottWilson-LaoPDR-2009-Slopes+Theme8.5+6+Retaining+Wall+Design+PPT+E-SEACAP21-v111220.pdf
- Policy Brief: Spring Revival through Sustainable Land Management (SLM) in the Himalayan Foothills: Uttarakhand, North India. Author: Liniger HP, Bandy J, Year: 2020: https://www.wocat.net/en/projects-and-countries/projects/onsite-and-offsite-benefits-sustainable-land-management/india
- Video: SLM for Himalayan Spring Revival. Author: Liniger HP, Bandy J, Year: 2020: https://vimeo.com/429988881