Pilewalls with additional mulch cover after 6 months; Protection by electric fence against grazing (Huber, M.)

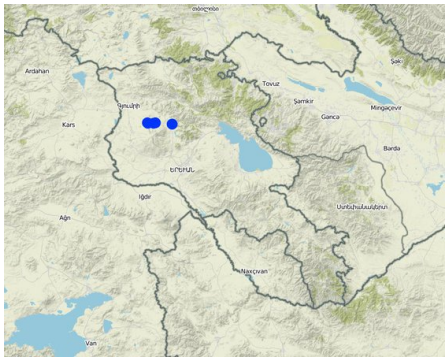
Slope erosion control using wooden pile walls (Armenia)

DESCRIPTION

Small horizontal wooden structures and terraces on eroded slopes built to mitigate sheet or rill erosion and slow down water run-off. The technology is easy to apply and efficient to mitigate erosion processes of the upper soil layer and to stop small rock falls.

In the provinces of Aragatsotn and Shirak in Armenia, the weather is cold and temperate with dry summer. Steep slopes, pastures and some autochthonous oak forests make up the area. Farmers make most of their income with grazing by manual labour. The carrying capacity of pastures in the vicinity is regularly exceeded, and they degrade more and more. In order to stabilize the steep eroded slopes, pile walls were established. Pile walls are horizontal constructions along a slope, functioning as erosion control measures by slowing down the superficial water runoff, retaining materials and supporting the rehabilitation of vegetation.
The major advantages are: It is not expensive since mostly locally available materials can be used, and a positive effect can already be observed within a year. Also, the pile walls can be established relatively easy without any need of heavy machinery or specific knowledge and, therefore, allow the involvement of the local population.
In the case of the implementation in Armenia, the exact location for the pilot measures was selected in such a way that grazing activities were almost not impaired. For temporary exclusion of livestock, electric fencing was used. Within the fenced area, pile walls were established in the washed-out rills along the slope to address the water erosion phenomena.
The technical requirements and workload for the construction of a pile wall are relatively low. The needed resources require iron piles, a hammer, wooden logs (or a bundle of branches) and tree cuttings. First, the wooden logs were cut in 1-2 m length to fit into the irregular rills of the slope. After identifying the locations of individual pile walls, the team fixed the logs with iron poles of about 70-100cm length. The distance between the pile walls varies between 1-3m, depending on the topography: the steeper the slope, the closer the distance. The space behind the logs was filled with soil, plant material and rocks to stabilize the construction and to reduce the risk of water washing out the soil and passing below the logs. As a last step, the terraces were covered with hay to provide protection against precipitation and to accelerate re-growth of grass through the seeds contained in the hay residuals.
Community members were surprised how easy and quick the pile walls could be established. A team of two workers established a pile wall within 30 min. Since these areas are usually intensively used and thus are of high importance for the community, even a temporary exclusion from use must be thoroughly discussed and agreed upon. The measure slows down vertical water-run off and provides steps for cattle. Due to temporary fencing and the application of hay mulch vegetation is recovering on these parts.

LOCATION



Location: Lusagyugyh, Hnaberd, Ghegadhzor, Saralandj, Mets Mantash, Aragatsotn and Shirak Marzes (Provinces), Armenia

No. of Technology sites analysed: 2-10 sites

Geo-reference of selected sites

- 44.38783, 40.60717
- 44.17575, 40.61962
- 44.15407, 40.61747
- 44.08078, 40.6189
- 44.08233, 40.61718

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

Date of implementation: less than 10 years ago (recently)

Type of introduction

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

Bioengineering site Geghadyor after the technology was implied (Michael Huber)

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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

Grazing land - Extensive grazing land: Semi-nomadism/ pastoralism
Main animal species and products: cattle (and sheep)

Water supply

- rainfed
- ✓ mixed rainfed-irrigated
- full irrigation

Number of growing seasons per year: 1

Land use before implementation of the Technology: n.a.

Livestock density: 0.89-1.30 pasture load/ha

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, Wm: mass movements/ landslides

soil erosion by wind - Et: loss of topsoil

physical soil deterioration - Pc: compaction

biological degradation - Bc: reduction of vegetation cover

SLM group

- pastoralism and grazing land management
- improved ground/ vegetation cover
- minimal soil disturbance

SLM measures

vegetative measures - V1: Tree and shrub cover, V2: Grasses and perennial herbaceous plants

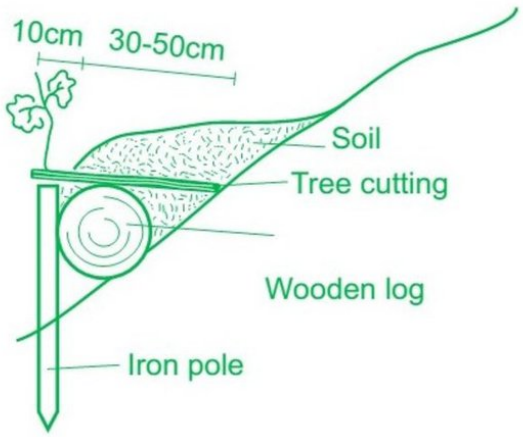
structural measures - S1: Terraces

TECHNICAL DRAWING

Technical specifications

Required materials for 1 pile wall:
- 2 iron poles (0.7-1m) and a hammer
- 1 wooden log (ca. 4 m, 20-25cm diameter)
- 10-20 shrub cuttings (e.g. Salix species)

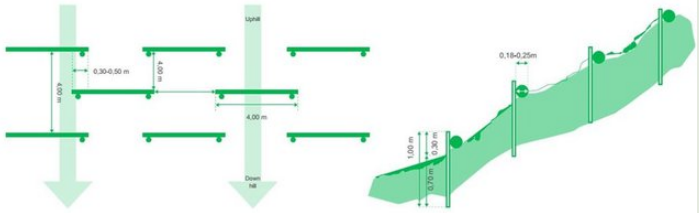
Selection of appropriate sites for pile walls (where and how to put them):
The logs are being spread on the slope as indictated in the scheme of the figure. The steeper the slope the narrower the vertical spacing in between (max. 4m, min. 1-2 m). On uneven slopes, place the along the depressions as these are the areas where water-run off is strongest. Parts which show no erosion signs can be left out to not destroy existing vegetation cover. The location of the pile walls is determined by the slope and serves to stabilize the slope at superficial level (10-30 cm). It landslides occur that involve deeper soil layers, this technology is not efficient.



Author: GIZ IBiS

Building process:
After placing the logs, those are fixed with two irons at the end (alternatively wooden posts can be used as well). After fixing the logs, the space behind needs to be filled (slight terracing of the slope). Additionally, either shrub seedlings or living cuttings from species such as willows (ca. 50cm long, 2-5cm diameter) should be integrated. Finally, the open soil should be covered by a layer of 2-5 cm of hay/grass containing seeds and eventually additional seeds (from local species) to promote the re-establishment of vegetation. This has also the benefit that this cover keep humidity in the soil, which is particularly important in (semi-)arid areas.

Species used/density:
At least 20 cuttings per pile wall should be planted. Depending on the survival rates, it can be also more. Shrubs additionally stabilize the slope and are to some extent protected by the pile wall.



Author: GIZ IBiS

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs
- Costs are calculated: per Technology area (size and area unit: **0.15 ha**)
- Currency used for cost calculation: **US Dollars**
- Exchange rate (to USD): 1 USD = n.a
- Average wage cost of hired labour per day: ca. 20 USD per worker and day (unskilled local workers), 120 USD per day (local expert)

Most important factors affecting the costs
Grazing (if fencing is needed it is the most costly part) Wooden logs (if bought). This can be turned to zero by either using local wood (if permitted) or bundles of branches of specific species (e.g. willows).

Establishment activities
1. Selection of eroded sites and size (Timing/ frequency: anytime)
2. Clarification of land user rights (Timing/ frequency: anytime)
3. Calculate amount of logs and irons needed (Timing/ frequency: anytime)
4. Materials check: Local materials and procurement of other materials (Timing/ frequency: anytime)
5. Place logs on the eroded slope (favor depressions where water flows are) (Timing/ frequency: anytime (best in spring and autumn))
6. Fix logs with two iron poles at both sides of the log (Timing/ frequency: anytime (best in spring and autumn))
7. Fill the space behind the log with soil, rocks and (willow) cuttings (Timing/ frequency: early spring or late autumn (willow cuttings without leaves))
8. Flatten the area behind the log (small terracing) (Timing/ frequency: anytime (best in spring and autumn))
9. Use additional hay/grass mulch to cover open soil and add additional seeds (Timing/ frequency: best in spring (alternatively in late autumn))
10. If it is grazing area: Fence the area for at least 2-3 vegetation periods (Timing/ frequency: during grazing period)

Establishment inputs and costs (per 0.15 ha)

Specify input	Unit	Quantity	Costs per Unit (US Dollars)	Total costs per input (US Dollars)	% of costs borne by land users
Labour					
Unskilled worker: Implementation of field measures	person days	30.0	21.0	630.0	10.0
Skilled expert (Implementation supervision and project management	person days	14.0	120.0	1680.0	
Transportation costs (truck, experts)	rental days	12.0	54.0	648.0	10.0
Administration costs	month	1.0	127.0	127.0	
Equipment					
Consumables	set	1.0	59.0	59.0	10.0
Electric tools	set	1.0	424.0	424.0	10.0
P3800 Fence energizer + Box and equipment	set	1.0	345.0	345.0	
Solar Panel for fence energizer	piece	1.0	233.0	233.0	
Battery and fence tester	piece	1.0	203.0	203.0	
Plant material					
Cuttings (20 per pile wall) (not used as it is being grazed)	pieces				
Hay/grass for mulch cover (Bales ca.20kg)	kg	800.0	0.08	64.0	
Construction material					
Wooden logs (3m, 20cm diameter)	pieces	50.0	17.0	850.0	
Iron poles (0.7-1m, 10 mm diameter)	pieces	150.0	2.1	315.0	
Electric Fence Polywire	m	1300.0	0.3	390.0	
Electric Fence Corner donut insulator	pieces	27.0	1.0	27.0	
Earth stakes	pieces	3.0	22.0	66.0	
Electric Fence Spring Gate Set	piece	1.0	42.0	42.0	
Wooden Posts	pieces	9.0	6.4	57.6	20.0
Total costs for establishment of the Technology				**6'160.6**	

Maintenance activities

1. Regular check of fence (Timing/ frequency: Once per two weeks)
2. Installation and deinstallation of electric fence (Timing/ frequency: Once per year)
3. Changing the broken posts (Timing/ frequency: once per year)
4. Optional refill of stones and/or soil if washed out (Timing/ frequency: twice per year)

Maintenance inputs and costs (per 0.15 ha)

Specify input	Unit	Quantity	Costs per Unit (US Dollars)	Total costs per input (US Dollars)	% of costs borne by land users
Labour					
Regular check of fence	workdays	8.0	21.0	168.0	100.0
Installation and deinstallation of electric fence	workdays	8.0	21.0	168.0	100.0
Changing the broken posts	workdays	1.0	21.0	21.0	100.0
Optional refill of stones and/or soil if washed out	workdays	3.0	21.0	63.0	100.0
Total costs for maintenance of the Technology				**420.0**	

NATURAL ENVIRONMENT

Average annual rainfall

- ☐ < 250 mm
- ☐ 251-500 mm
- ☑ 501-750 mm
- ☐ 751-1,000 mm
- ☐ 1,001-1,500 mm
- ☐ 1,501-2,000 mm
- ☐ 2,001-3,000 mm
- ☐ 3,001-4,000 mm
- ☐ > 4,000 mm

Agro-climatic zone

- ☐ humid
- ☐ sub-humid
- ☑ semi-arid
- ☐ arid

Specifications on climate

Average annual rainfall in mm: 521.0
In Aparan, the climate is cold and temperate. Aparan has a significant amount of rainfall during the year. This is true even for the driest month. Precipitation peaks are in May and June.
Name of the meteorological station: Aparan, Aragatsotn Marz, Armenia
According to Köppen and Geiger, the climate is classified as Dfb (Cold/continental, no dry season, warm summers). Annual mean temperature is 5.2. °C. The warmest month of the year is August, with an average temperature of 16.4 °C. January has the lowest average temperature of the year with -6.9 °C.

Slope

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

Landforms

- ☐ plateau/plains
- ☐ ridges
- ☑ mountain slopes
- ☐ 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.
- ☐ 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
- ☑ not relevant

Soil depth

- ☐ very shallow (0-20 cm)
- ☑ shallow (21-50 cm)
- ☑ moderately deep (51-80 cm)
- ☐ deep (81-120 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%)

- [ ] very deep (> 120 cm)

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

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

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

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

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

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
- [ ] 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
- [x] 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
- [ ] elderly

Area used per household
- [ ] < 0.5 ha
- [ ] 0.5-1 ha
- [x] 1-2 ha
- [x] 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
- [x] state
- [ ] company
- [x] communal/ village
- [ ] group
- [ ] individual, not titled
- [ ] individual, titled

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

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

Access to services and infrastructure

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

IMPACTS

Socio-economic impacts

fodder quality	decreased	✓	increased
workload	increased	✓	decreased

The erosion control masures stopped top soil Erosion and Gully Erosion in the pasture land.

The workload for implementing the measures does not pay off within the first view years but is a long term investment in saving soil productivity.

Socio-cultural impacts

SLM/ land degradation knowledge	reduced	✓	improved

The intervention raised awareness to soil erosion and new technologies have been trained to village stakeholders (pile walls, electric fencing)

Ecological impacts

water quantity	decreased	✓	increased
evaporation	increased	✓	decreased

Water run off is decreased and soil moister is increase by better infiltration of water into the soil.

The increase of vegetation leads to an increase of evaporation-transpiration.

soil moisture	decreased	increased	Water run off is decreased by pile walls and better vegetation cover and soil moister is increase by better infiltration of water into the soil.
soil loss	increased	decreased	Decrease of water run off by pile walls and increased vegetation cover leads to decrease of soil loss.
soil organic matter/ below ground C	decreased	increased	Increase of vegetation leads to more root activity and humus increase by increase of litter.
vegetation cover	decreased	increased	The stop of grazing and trampling by the fence leads to fast increase of vegetation cover.
biomass/ above ground C	decreased	increased	The stop of grazing leads to significant increase of above ground biomass.
plant diversity	decreased	increased	On heavily eroded sites the measure lead to increase of plant species.
fire risk	increased	decreased	The increase of above soil biomass increase the risk of grass-fire in autumn during or after the dry season.

Off-site impacts

buffering/ filtering capacity (by soil, vegetation, wetlands)	reduced	improved	through increased vegetation cover and reduced speed of superficial water-runoff and increase of water capacity of the slope above the village.
wind transported sediments	increased	reduced	partially improved through increased vegetation cover and less open soil

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

On the short term there is a significant increase of work load and needed resources to establish the pile walls and fencing the site. Recovery of vegetation, increase of soil carbon content and increase of productivity will need 2-5 years to be effective and give increase fodder yields of the site.

CLIMATE CHANGE

Gradual climate change

annual temperature increase	not well at all	very well	
seasonal temperature increase	not well at all	very well	Season: winter
seasonal temperature increase	not well at all	very well	Season: summer
annual rainfall decrease	not well at all	very well	
seasonal rainfall increase	not well at all	very well	Season: spring
seasonal rainfall increase	not well at all	very well	Season: autumn
seasonal rainfall decrease	not well at all	very well	Season: winter
seasonal rainfall decrease	not well at all	very well	Season: summer

Climate-related extremes (disasters)

drought	not well at all	very well
land fire	not well at all	very well

ADOPTION AND ADAPTATION

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

- [x] single cases/ experimental
- [ ] 1-10%
- [ ] 10-50%
- [ ] more than 50%

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

- [x] 0-10%
- [ ] 10-50%
- [ ] 50-90%
- [ ] 90-100%

Number of households and/ or area covered

There are interested households who want to adopt the technology, but indeed there is nobody who implemeted the technology by himself/herself.

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

- [x] Yes
- [ ] No

Due to unavailablity of local seeds, local hay/grass was used to provide mulching cover and add locally adapted seeds On one site an additional drainage trench was prepared as the soil was

To which changing conditions?

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

very compacted and vegetation cover was completely destroyed. The trench was filled with rocks which are available in abundance.

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Improvement of road of animals, improvement of quality of pasture and vegetation cover, overcome of erosion, regulation of water flow, better view of the area, dissemination of seeds to other areas

Strengths: compiler's or other key resource person's view

- Technology is easy to apply and works mostly with local materials and requires no specific knowledge. Materials can be adapted (e.g. if timber is scarce, bundles of willow branches can be used as alternative)
- Technology is able to stabilize superficial erosion processes and support recovery of vegetation on steep slopes. It can also stop small rock falls.
- Technology can also be adapted to fortify/stabilize paths and cattle paths on slopes (e.g. when a walking path is crossing a small gully section). Thus, it can also stop erosion processes caused by trampling or hikers

Weaknesses/ disadvantages/ risks: land user's view → how to overcome

- Limited availability of material such as electric fence, solar panels, etc in the local market → At the moment they can be imported
- relatively high cost for material → Using cheap and local material
- Limitation of cattle road → Use other alternative road for animals

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's view → how to overcome

- If not installed properly, water flows on the sides of the pile walls and below and the barrier becomes ineffective → Take care during construction that the space below the logs is filled appropriately.
  Take care of appropriate re-establishment of a vegetation cover
- If area is being grazed, it is challenging to re-establish vegetation. Cuttings which further stabilize the slope are unlikely to succeed. → Temporary fencing of the area or permanent fencing and use of area for hay making

REFERENCES

Compiler
Hanns Kirchmeir (office@e-c-o.at)

Reviewer
Ursula Gaemperli (ulla.gaemperli@cde.unibe.ch)

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Resource persons
Aghasi Mnatsyan (aghasi.mnatsyan@giz.de) - SLM specialist
Hrant Khachatryan (hkhachatryan84@gmail.com) - SLM specialist
Michael Huber (huber@e-c-o.at) - SLM specialist

Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_4092/

Linked SLM data
Approaches: Participative Slope Stabilization https://qcat.wocat.net/en/wocat/approaches/view/approaches_745/

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- GIZ Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)

Project

- Integrated Biodiversity Management, South Caucasus (IBiS)

Key references

- Handbook on Integrated Erosion Control A Practical Guide for Planning and Implementing Integrated Erosion Control Measures in Armenia, GIZ (ed.), 2018, ISBN 978-9939-1-0722-6: GIZ Armenia

Links to relevant information which is available online

- Project website of the GIZ program: http://biodivers-southcaucasus.org/