Soil-Ferro Cement Retention Ponds

Nepal – स्वायल-फेरो सिमेन्ट पुर्नधारण पोखरी

Soil-ferro cement water retention ponds for individual households.

Soil-ferro cement ponds with ferro-cement lining complement rooftop rainwater harvesting (RWH) jars at the household level (QT NEP 46) by adding storage facilities which retain overflow and waste water from the water jars, as well as from additional roof catchments. Consistent with the application area of the ferro cement jars, the retention ponds are implemented primarily in poor, water-scarce areas of the Nepal mid-hills, where gravity flow systems (QT NEP 40) are deemed unfeasible on technical or financial grounds. Although generally attached to rainwater jars, rooftop rainwater harvesting systems with soil-ferro cement ponds can also be implemented as a stand-alone technology to enable small-scale irrigated agriculture and provide (additional) water for livestock and sanitation purposes in water-short areas. When implemented independently, water from spring sources may be tapped instead or in addition to rainwater. Most of the households make use of the stored pond water by cultivating small vegetable gardens.

The primary targeted group of this technology is financially and socially deprived communities, living mostly from subsistence farming. Even though average annual precipitation in the project area amounts to about 1,600 mm, it features high inter-annual variability, including a pronounced dry season. As a result, many water sources, especially in higher elevated regions, along ridgelines dry up substantially in the dry summer months.

While the stored water in the ferro-cement jars (storage volume of 6.5 m^3) alleviates the most serious hardship related to water scarcity, the supplied water (on average 55 l/day per jar) can only partially fulfill domestic water demands. Households are thus still dependent on possibly remote and/or intermittent ground and surface water sources. The additional storage volume provided by the retention ponds reduces the need to fetch water for irrigation purposes during dry periods, thus freeing up other water sources (springs, jars) for more domestic use.

The designated pond volume of 3 m^3 is based on irrigational water supply requirements for a kitchen garden of 50 m^2. To reliably fill and utilize the ponds to their maximum storage capacity of 3 m^3, the roof catchment area attached to the pond should span at least 8 m^2, thus providing – on average – 30 l per day. Corrugated galvanized iron (CGI) sheets are used as roof catchment surfaces, ensuring minimal collection losses and remaining corrosion-free over long time periods. HDPE pipes (roof gutter and downpipes) then collect and transport the roof water to the rectangular-shaped retention pond.

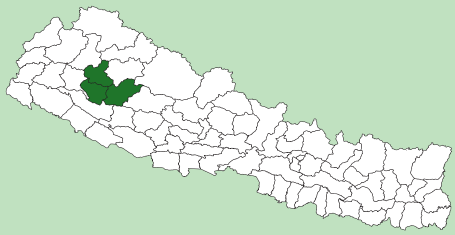
The well-compacted walls of the excavated pond are plastered with a thin base layer of soil-cement. Then, a ferro-cement lining – a mixture of Portland cement and sand reinforced with layers of chicken wire mesh – is applied. While ferro-cement is more expensive, it also makes for a more durable pond lining than plastic varieties, which become especially vulnerable if the ponds are left empty (QT NEP 42). Concurrently, the ferro-cement lining minimizes seepage and comes with low required maintenance, which is mainly limited to removing accumulated sediments and preventing livestock and humans from entering the pond.

Capacitated local village workers) chiefly manage the establishment of the ponds. The community contributes with local materials and by carrying out all unskilled labor works, whereas the programme covers expenses related to skilled labor works, as well as procurement and road transportation of non-local construction materials.

To facilitate irrigation projects on a community level, larger soil-ferro cement ponds with storage volumes of 6 or 10 m^3 are implemented occasionally. In this case, pond dimensioning is guided by the amount of surplus water (e.g., from gravity flow schemes) and the irrigated area.

Left: Roof rainwater harvesting jar (QT NEP 46) with attached rainwater harvesting pond, which retains excess water. (WARM-P)

Right: Rainwater harvesting pond with roof catchment area. (WARM-P)



Location: Three districts in the Mid-Western Development Region of Nepal: Dailekh, Jajarkot, and Kalikot

Conservation measure(s): Structural

Land use type: Settlements

Climate: Humid subtropical

WOCAT database reference: QT NEP 47

Related approach: QA NEP 36

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Comments: Rooftop rainwater harvesting ponds are an add-on to the ferro-cement jar technology and are part of the water supply measures planned and implemented within the Water Use Master Plan (WUMP) framework for poor communities in the rural mid-hills of Nepal.

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

HELVETAS Swiss Intercooperation NEPAL

ICIMOD

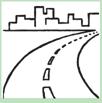
WOCAT

Classification

Water use problems

- Growing water demand for both domestic and agricultural use and diminishing or fluctuating water supply due to climate change
- Water sources are intermittent and/or far away; households spend upward of two hours on water fetching
- Need for a water storage technology on the household level which strikes a balance between cost and durability

Land use



Settlements, Infrastructure

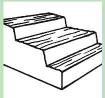
Climate

Humid subtropics

Degradation

Physical degradation: Local water scarcity

Conservation measure(s)



Structural: pond

Stage of intervention

Prevention
Mitigation/reduction
Rehabilitation

Origin

Land users' initiative:
Experiments/research
Externally introduced: 10-50 years ago

Level of technical knowledge

Field staff
Land user

Main causes of local water scarcity

- **Natural causes:** temporary water scarcity during dry season (Dec.-May); higher fluctuations in supply due to change in seasonal rainfall patterns; diminishing supply and increasing water demand due to increase in temperature
- **Human-induced causes:** poor water governance; lack of infrastructure; increase in water demand due to to progressively higher living standards and augmented agricultural production

Main technical functions

- improve water access and increase water supply

Secondary technical functions

- none

Legend

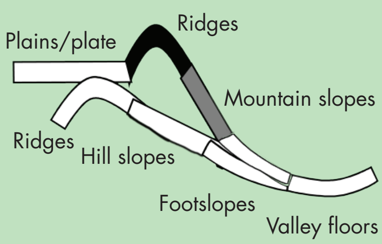
high
moderate
low
insignificant

Environment

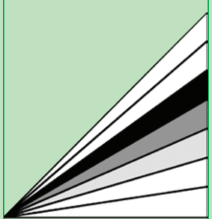
Natural environment

Average annual rainfall (mm)	Altitude (masl)
>4000	>4000
3000-4000	3000-4000
2000-3000	2500-3000
1500-2000	2000-2500
1000-1500	1500-2000
750-1000	1000-1500
500-750	500-1000
250-500	100-500
<250	<100

Landform

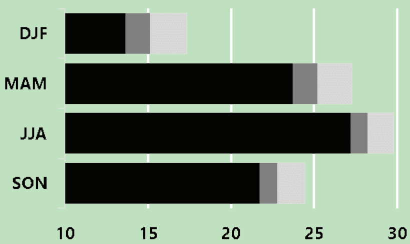


Slope (%)

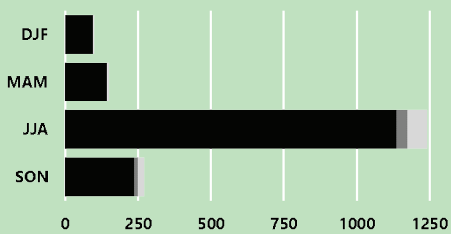


Climate change[1]

Temperature (T) in °C



Precipitation (P) in mm



– Future **T** increase projected to be most pronounced in dry season

– **P** projections still with large uncertainty; **P** predicted to stay constant or slightly decrease in winter (DJF) and increase during the monsoon period (JJA)

→ Possibility of more frequent winter droughts and summer floods

Historical climate: 1976 - 2005
Future climate: 2020 - 2039
Future climate: 2040 - 2059

Tolerant of climatic extremes: temperature increase; wind storms/dust storms; floods; decreasing length of growing period

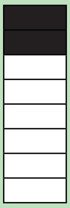
Sensitive to climatic extremes: seasonal rainfall increase/decrease; heavy rainfall events (intensities and amount); droughts/dry spells

If sensitive, what modifications were made/are possible: increase storage volume (e.g., by adding overflow pond)

[1] Historical climate is drawn from local observational records. Future **T** and **P** anomalies are based on the ensemble median of 15 climate models employed in IPCC AR4 representing the SRES B1 emission scenario. Source: World Bank Climate Change Knowledge Portal

Human environment

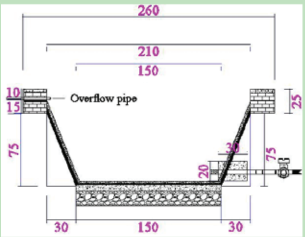
Cropland per household (ha)

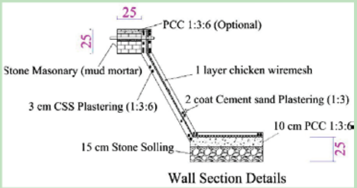


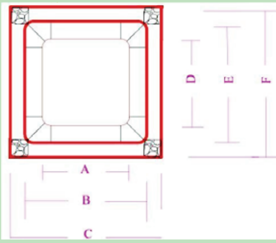
<0.5
0.5-1
1-2
2-5
5-15
15-50
50-100
100-500

Land user: individual/household, small-scale land users, disadvantaged land users, men and women
Population density: 120 persons/km^2
Annual population growth: 1-2%
Land ownership: individually owned/titled
Land use rights: individual
Water use rights: communal (organised)

Relative level of wealth: very poor and poor, which represent 39% and 27% of population in the area, respectively.
Importance of off-farm income: less than 10% of all income
Access to service and infrastructure: low: health, technical assistance, employment, market, energy, financial services; moderate: education; roads and transport; drinking water supply and sanitation
Market orientation: mainly subsistence (self-supply)







Technical drawing

Upper Left:

Pond cross-section

(size indications in cm)

Upper right:

close-up of wall section

(size indications in cm)

Bottom:

Pond dimensions for different storage volumes

Implementation Activities, Inputs, and Costs

Establishment activities

Establishment is carried out under the supervision of local service providers using construction tools, which include measuring tape, spade, shovel, knife, hoe, hammer, trowel, and pan. Establishment can be completed in one week. The major establishment activities are as follows:

1. Selection of suitable site
2. Site clearance; measure and outline pond area
3. Excavation of pond to a depth of 1.1 m, remove protruding stones
4. Sole pond floor with stones (15 cm); apply sand filling to create a smooth surface
5. Stone masonry of walls with mud mortar (25 cm)
6. Apply a 7.5 cm plain cement concrete layer on pond floor (cement-to-sand to aggregate ratio of 1:2:4)
7. Apply a 3 cm-thick layer of cement-sand-soil plastering (1:3:6 ratio) on walls
8. Lay out a layer of chicken wire mesh on floor and walls and fix with u-nails
9. Apply two coats of 12.5 mm-thick cement plastering (cement-to-sand ratio of 1:3)
10. Apply a cement slurry painting
11. Level terrain around the pond
12. Install roof catchment area, as well as HDPE pipe gutter and conveyance system

Typical establishment inputs and costs per 3 m^3 pond

Inputs	**Costs (US$)**[1]	**% met by users**
Skilled Labour (4.5 person days)	24	0
Unskilled Labour (15 person days)	53	100
Construction Materials		
• Cement (150 kg)	22	0
• HDPE and GI pipes	6	0
• Chicken wire mesh (12 m)	13	0
• Other construction materials	4	0
Local Materials (costs reflect unskilled labour effort for collection and portering)		
• Stone (1.2 m^3)	13	100
• Sand (0.55 m^3)	19	100
• Aggregate (0.2 m^3)	5	100
• Soil (0.55 m^3)	1	100
Total	**160**	**57**

[1] Exchange rate as per June 2015 USD 1 = NRs 100

Maintenance/recurrent activities

1. Prevent livestock and humans from entering the pond
2. Regularly clean gutter system to remove obstructing material
3. Cleaning pond once or twice a year by removing the accumulated sediments

Maintenance/recurrent inputs and costs per pond per year

Inputs	**Costs (US$)**	**% met by users**
Labour (2 person days)	7	100%
Total	**7**	**100%**

Remarks: The above cost breakdown is based on design cost estimates for the period from 2010 to 2014. Costs for portering and road transportation of non-local materials – very much subject to the remoteness of the project site – were omitted. Community contribution to the overall costs (including project management and all transportation costs for non-local materials) is typically between 50% and 60%.

The few necessary operations and maintenance activities are carried out by the users themselves. Repair works are taken over by rain water harvesting mistris ("mistri" is a Nepali word meaning a skilled worker) and are paid for by the users on an individual basis. In schemes where an O&M fund was introduced, repair works are financed by the fund, which is managed by the scheme's User Committee.

Assessment

Impacts of the technology			
Production and socioeconomic benefits		**Production and socioeconomic disadvantages**	
+ +	Increased irrigation water availability (~10 m³ per year) Given established market access, irrigation of vegetables and cash crops can raise household income	–	Loss of land (to accommodate pond)
+	Decreased workload; reduced time for water fetching		
Sociocultural benefits		**Sociocultural disadvantages**	
+ +	Improved food security/self-sufficiency, more nutritious diet.		None
+	Improved sanitation and hygiene level		
Ecological benefits		**Ecological disadvantages**	
+ + +	Improved harvesting/collection of water		
Off-site benefits		**Off-site disadvantages**	
	None		None
Contribution to human well-being/livelihoods			
+ +	Decreased workload due to reduced time for water fetching. The saved time is reported to be spent on livestock raising, vegetable cultivation, and household chores.		
+++: high / ++: medium / +: low			

Analysis of benefits and costs	Benefits compared with costs	short-term	long-term
Most of the users (~90%) utilize the stored water for kitchen gardening. The additional vegetable production is valued highly. Without outside assistance, the establishment costs of soil ferro-cement ponds are prohibitively high for most users. Maintenance costs are perceived as manageable.	Establishment	negative	positive
	Maintenance/recurrent	neutral	positive

Acceptance/adoption
The implemented technologies are identified and prioritized based on inclusively planned WUMPs (QA NEP 36). Moreover, representatives of the community take a lead role in the detailed planning and implementation process, resulting in a high acceptance rate of the technology; virtually all households are making use of their water pond. There are several reports of spontaneous adoptions by neighboring communities upon seeing the implemented retention ponds. Replicated ponds tend to have plastic linings to economize on establishment costs and simplify construction.

Concluding Statements

Strengths and ➔ how to sustain/improve	Weaknesses and ➔ how to overcome
The stored water mainly serves the cultivation of small kitchen gardens (~90% of all ponds), thus increasing the availability of vegetables. Less frequently, the pond water is used for cattle feeding or sanitation purposes ➔ Provide training on kitchen garden farming techniques and on balanced nutrition to maximize impact of irrigational water	The programme provides fencing around the ponds for the larger community pond options (6/10/15 m³) and recommends that users build a fence for household ponds (3 m³) with local materials to prevent children and cattle from falling in. However, some (~20%) of the households never build such a fence ➔ consider making programme support conditional on the user's willingness to provide pond fencing on their own
The pond water helps households to meet the irrigational water demand, thus freeing up other water sources (springs, jars) for domestic usage ➔ ensure that the increased household water supply results in improved health outcomes by combining establishment of ponds with toilet construction, hygiene awareness, as well as household water treatment and storage education campaigns	The supplied water can only partially fulfill irrigational water demands. Households are thus still dependent on possibly remote and/or intermittent ground and surface water sources, especially to fulfill their domestic water needs ➔ (i) increase yield of existing sources by implementing source conservation and improvement); (ii) consider solar lifting schemes to cater to communities where gravity flow systems are not feasible
Straightforward and virtually maintenance-free operation render retention ponds well-suited for replication ➔ capacitated village maintenance workers spread the word and support adoption by neighboring communities by assisting in the procurement of materials and the construction process	Poor households may face difficulties in procuring non-local construction materials such as cement, HDPE, and GI pipes, lowering spontaneous adoption rates ➔ secure additional funding by disseminating and marketing WUMP (); capacitate user committees in procurement of construction tools and materials
The soil ferro-cement lining steers a middle course between costs and durability. After two years, 95% of the ponds were fully functional and the remaining 5% in need of minor repairs within the capacity of the community ➔ Ensure good workmanship and quality in construction by selecting construction supervisors with care	Soil-ferro cement ponds are based upon empirical design. Further monitoring (five to 10 years after construction) is needed to learn about long-term durability performance ➔ perform long-term functionality studies

Key references: SWISS Water & Sanitation NGO Consortium (2013) Beneficiary Assessment of WARM-P, Nepal. Lalitpur, Nepal: WARM-P/HELVETAS;
HELVETAS (2013) The Effectiveness and Outcomes of Approaches to Functionality of Drinking Water and Sanitation Schemes. Lalitpur, Nepal: WARM-P/HELVETAS

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