Pond Irrigation System

Nepal – पोखरी सिंचाई योजना

Pond irrigation systems with plastic-lined ponds for smallholder farmers in water-scarce areas in the mid-hills of Nepal.

While traditional farmer-managed canal irrigation systems (QT NEP 41) are prevalent in the Nepal mid-hills, they tend to be located at accessible locations in the river valleys and terraced uplands. On the other hand, lacking irrigation facilities impedes the ability of farmers in higher-elevaation and water-scarce areas to enhance and diversify their agricultural production. The pond irrigation systems described here provide decentralized irrigation facilities which aim to increase agricultural productivity and create opportunities for diversification of cropping patterns for smallholder-farming households (on average 0.14 ha irrigated command area) in marginal areas of the mid-hills of Nepal.

Pond irrigation systems generally comprise the following parts: (i) intakes at one or several water sources, (ii) HDE pipes, which convey the extracted water, (iii) flow-regulating chambers, which distribute the water to one or several (iv) ponds; (v) water taps connected to the ponds serve as irrigation outlets. The system design adheres to the following principles:

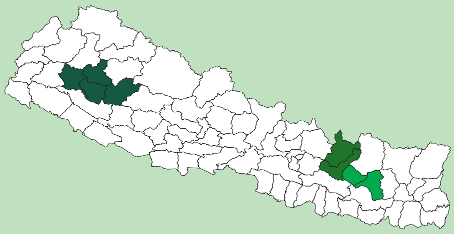
- **Minimum source yield:** The tapped water sources should guarantee at least 300 liters per Ropani per day (a Ropani is a Nepalese customary unit of measurement and is equivalent to 509 m^2). For the most part, the programme makes use of perennial spring water sources located uphill of the scheme. The minimum source yield is determined in the dry pre-monsoon months of April and May.
- **Mean irrigation demand:** Water demand for irrigation is subject to cropping patterns and employed irrigation methods. For the program's standardized pond design, the average water demand is presumed to be 500 liters per Ropani per day, equivalent to 1 $l/m^2/d$.
- **Peak demand:** Peak demand is assumed to be three times the average demand, or 1,500 liters per Rop. and day.
- **Limited pipe length:** Management and upkeep efforts increase considerably in systems with large pipe networks. Therefore, the maximum total pipe length is limited to 10 km.
- **Command Area Coverage:** Total irrigated areas connected to one pond range between 10 and 40 Ropani (0.5 – 2 ha).
- **Pond capacity:** Ponds are built in dimensions that either meet the peak demand for one day or can store two days' worth of average source yield (choosing the minimal volume of the two options). Ponds are implemented with capacities of 15 m^3, 30 m^3, 45 m^3, and 60 m^3.
- **Pond lining:** The excavated ponds are lined with Silpaulin sheets. This watertight, plastic-like material tends to become brittle when exposed to direct sunlight, i.e., when the ponds are empty. Jute bags filled with a soil-cement mixture (ratio of 10:1) cover and protect the plastic lining from direct exposure and other potentially damaging sources.
- **Pond fencing:** Barbed wire fencing prevents children and cattle from entering the pond area.
- **Water sharing policy:** Due to the water-scarce conditions, the water-sharing policies for ponds usually foresee the allocation of equal water volumes to all beneficiaries irrespective of the individual land holding (see also QA NEP 41).

The standardized designs are then adapted according to local needs and circumstances, namely local water availability, water requirements of the proposed crops, and agreed-upon pond operation rules with the farmers. A typical irrigation scheme consists of two to five ponds, each catering to three to five user households.

The irrigation schemes lead to an increase in agricultural production and a greater variety of crops, i.e., staple cereals are partly replaced by vegetables (cash crops). This contributes to both an increase in food sufficiency and a healthier diet. Depending on market access, the increased production allows farmers to sell part of the crops and augment their income.

Left: Pond construction in difficult terrain for the Mulkhola pond irrigation scheme, Sukatiya VDC, Kalikot district. (LILI)

Right: Pond excavation at Gortikhola Pond Irrigation Scheme, Kashikadh VDC, Dailekh District. (LILI)



Location: 8 districts in the Central, Eastern and Mid-Western Development Regions of Nepal

Technology area: per scheme: 1 – 10 km^2

Conservation measure(s): Structural

Land use type: Settlements

Climate: Humid subtropical

WOCAT database reference: QT NEP 43, 42

Related approach: QA NEP 41 and QA NEP 36

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Comments: The here described pond irrigation systems are part of the irrigation measures planned and implemented within the Water Use Master Plan (WUMP) framework for poor communities in the rural mid-hills of Nepal.

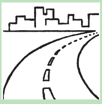
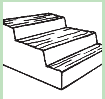
The technology was documented using the WOCAT (www.wocat.org) tool.

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 and socioeconomic changes
- Water sources are intermittent and/or far away; households spend upward of two hours on water fetching
- Lack of irrigation water and agricultural inputs result in poor agricultural productivity and food insecurity

Land use	Climate	Degradation	Conservation measure(s)
			
Settlements, infrastructure	Humid subtropics	Physical degradation: local water scarcity	Structural: canals

Stage of intervention	Origin	Level of technical knowledge
Prevention Mitigation/reduction Rehabilitation	Land users' initiative: 100 years ago Experiments/research Externally introduced: 10-50 years ago	Field staff Land user

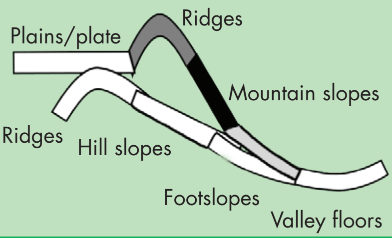
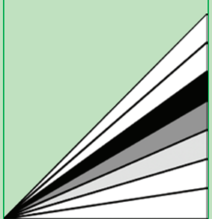
Main causes of local water scarcity

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

Main technical functions	Secondary technical functions	Legend
• improve access to irrigation water	• None	high moderate low insignificant

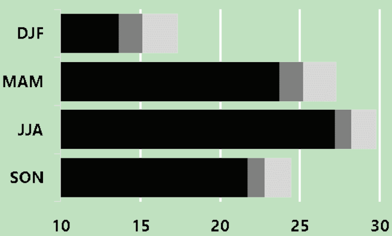
Environment

Natural environment

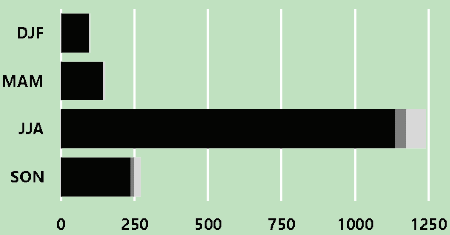
Average annual rainfall (mm)	Altitude (masl)	Landform	Slope (%)
>4000 3000-4000 2000-3000 1500-2000 1000-1500 750-1000 500-750 250-500 <250	>4000 3000-4000 2500-3000 2000-2500 1500-2000 1000-1500 500-1000 100-500 <100		 very steep (>60) steep (30-60) hilly (16-30) rolling (8-16) moderate (5-8) gentle (2-5) flat (0-2)

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: wind storms/dust storms; floods; decreasing length of growing period

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

If sensitive, what modifications were made/are possible: consider increasing storage volume and source conservation measures

[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

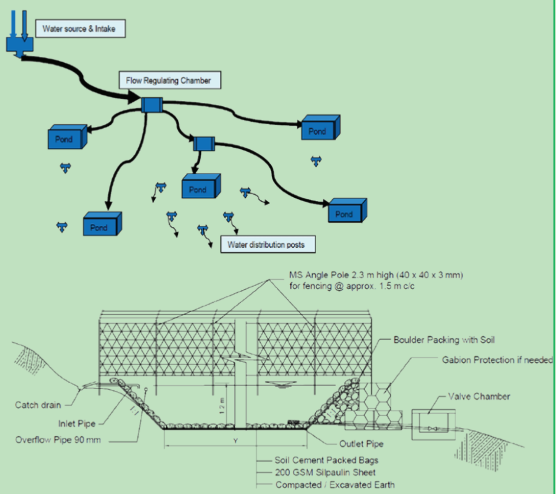
Human environment

Cropland per household (ha)

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

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 & transport, drinking water supply and sanitation
Market orientation: mainly subsistence (self-supply)



Technical drawing

Top: a typical pond irrigation system layout

Bottom: typical pond cross-section

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 is carried out in the dry period and can be completed in five-six days.

1. Select a suitable, preferably flat, site with stable uphill slope conditions.
2. Site clearance; measure and outline pond area.
3. Excavate the pond, remove protruding stones.
4. Compact and smooth pond floor and walls.
5. Install inlet, outlet, and overflow pipes.
6. Spread clay paste on walls and floor to create a smooth surface.
7. Lay out the 200 GSM Silpaulin sheets without any folds over the pond, with overlapping at any joints.
8. Overlay fine soil on the plastic sheet.
9. Anchor the edges of the sheet at the rim of the pond with stones and soil.
10. Cover sheet with soil cement (10:1) -packed bags (jute or used cement bags).
11. Dig a catch drain on the uphill side with a two-way slope.
12. Add gabion protection on the downhill side (if needed).
13. Erect barbed wire fencing around the pond.

Typical establishment inputs and costs for a pond with 15 m^3 capacity (for 5-9 households)

Inputs	Costs (US$)[1]	% met by users
Skilled Labour (4 person days)	20	0
Unskilled Labour (30 person days)	105	100
Construction Materials		
Cement (600 kg)	85	0
200 GSM Silpaulin sheet (49 m^2)	60	0
MS angle poles (16 pieces)	65	0
Barbed wire (25 kg)	25	0
Jute bags (185 pieces)	85	0
Inlet, Outlet, Overflow pipe	50	0
Local Materials		
Sand and Aggregate	25	100
Excavated soil for filling of jute bags	350	100
Total	**530**	**26**

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

Maintenance/recurrent activities

1. Ensure year-round submergence of the pond.
2. Clean pond once or twice a year by removing the accumulated sediments.
3. Monitoring of structures (intake, distribution lines, flow-regulating chamber) by walking along the pipeline network.

Maintenance/recurrent inputs and costs per household per year

Inputs	Costs (US$)	% met by users
Labour and equipment	7	100%
Total	**7**	**100%**

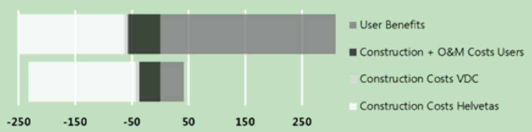
Remarks: The above cost breakdown is based on design cost estimates for the period from 2010 to 2014. Costs for portering and road transportation of non-local materials – very much subject to the remoteness of the project site – as well as project management costs were omitted. If feasible, non-local construction materials are procured by the community and paid by the programme. Village Development Committees (VDC) contribute on average about 3% to the overall costs. Community contribution to the overall costs (including project management and all transportation costs for non-local materials) is typically between 10% and 15%. This includes collection and portering of local materials, as well as unskilled labour work for trench digging, pond excavation, and supporting construction works. The programme reimburses the unskilled labour required for the construction of the intake structure and the idle length of the main pipe. Total average investment costs per scheme (including intake, transmission line, distribution chamber, and multiple ponds) amount to about USD 11,000, with costs for individual ponds ranging between USD 500 (15 m^3) and USD 1,150 (60 m^3). Construction of the main transmission pipe makes up about half of the total scheme costs.

In each scheme, a paid caretaker carries out the operation and maintenance activities. The O&M activities are financed out of the scheme's O&M fund, which is managed by the scheme's User Committee During scheme construction, cash equivalent to 3% of the scheme's total cost is raised for the O&M fund. Thereafter, users contribute cash and food grain on a monthly basis to pay for the caretaker's salary and finance O&M works. Individual cash contributions range from USD 0.1 to 0.25 per Ropani per month.

Assessment

Impacts of the technology			
Production and socioeconomic benefits		**Production and socioeconomic disadvantages**	
+ + +	Increased irrigation water availability, enabling increased agricultural productivity and diversified crop patterns	– –	Loss of land (to accommodate ponds)
+ +	Given established market access, irrigation of vegetables and cash crops can raise household income		
Sociocultural benefits		**Sociocultural disadvantages**	
+ +	Improved food security/self-sufficiency, more nutritious diet		None
+ +	Strengthened community spirit and fewer quarrels over water due to settled water distribution agreements		
Ecological benefits		**Ecological disadvantages**	
+ +	Increased soil moisture		
Off-site benefits		**Off-site disadvantages**	
+	Reduced risk of downstream flooding		
Contribution to human well-being/livelihoods			
+ +	Increased production and greater variety of crops help people to increase food sufficiency. Vegetables contribute to a healthier diet.		
+++: high / ++: medium / +: low			

Discounted economic costs and benefits per household (USD)



Assumptions

- **Average scheme cost per HH:** USD 230
- **Net average incremental benefit per ha and year:** USD 675. Assume benefit will be 50% in first year and 100% from second year onward
- **Average command area per HH:** 0.14 ha
- **Scheme life:** 10 years
- **O&M costs per HH:** USD 7 per year
- **Discount rate:** 10%

Under the above assumptions, the break-even point is reached after four years. The net present value per HH (for an assumed lifetime of 10 years) is around USD 260. The scheme has a Benefit/Cost Ratio of 1.97 and an Economic Internal Rate of Return (EIRR) of about 30%.

Acceptance/adoption

Moreover, representatives of the community take a lead role in the detailed planning and implementation process and in the development of equitable water policies, resulting in a high acceptance rate of the technology; virtually all households are making use of their water ponds. In recent years, governmental agencies have started to replicate and promote pond irrigation schemes in other regions.

Concluding Statements

Strengths and ➔ how to sustain/improve	Weaknesses and ➔ how to overcome
The irrigation schemes can help the farmers increase their agricultural production and cultivate a greater variety of crops ➔ support partial shift from cereals to high-value but low water-demanding crops by linking farmers to agricultural service providers and develop their capacity to devise suitable post-construction cropping patterns and irrigation schedules	Due to failing O&M mechanisms, some schemes become partly or fully dysfunctional much ahead of their designed operational lifetime. Operation and Maintenance of pond irrigation systems differs substantially from traditional Nepalese canal irrigation systems; the user communities therefore require a lead time to get acquainted with the technology and to develop the capacity to look after the system independently ➔ ensure post-construction support and mentoring for the first couple of years; link pond systems to VDC/DDCs for long-term support
As crop patterns get more diverse, surplus cash crops and vegetables may be sold to increase the household income ➔ coordinate with other programs to help establish market access in remote regions; support collection and storing centers or processing facilities for vegetables	Big ponds (>150 m^3) were noted to have higher failure rates caused by the development of cracks and faults on the pond walls and floor ➔ in later project stages, the programme stepped away from large ponds and turned toward implementing batteries of smaller ponds (30 m^3 – 60 m^3) in their stead
If market access and links to agricultural service providers are established, the associated economic benefits incentivize users to maintain their system ➔ consider promoting pond schemes primarily in areas with access to markets and agricultural services	In water-scarce areas and especially on ridgelines, it may prove impossible to find adequate perennial water sources in the vicinity of the community ➔ consider rainwater harvesting ponds or source conservation and recharge measures to increase source yields
Plastic-lined ponds are less costly and require less skill and workmanship to construct and maintain than masonry or concrete ponds. System defects can be corrected quickly and with comparatively low costs ➔ ensure good workmanship and system upkeep by capacitating the local service providers supporting the construction process, as well as the caretakers in charge of maintenance and repair activities	SILPAULIN sheets are often not available in local markets and are rather expensive for poor farmers, hampering repair works in case of punctured sheets ➔ consider subsidising sheets for poor communities; link pond communities to VDC/DDCs for long-term support

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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