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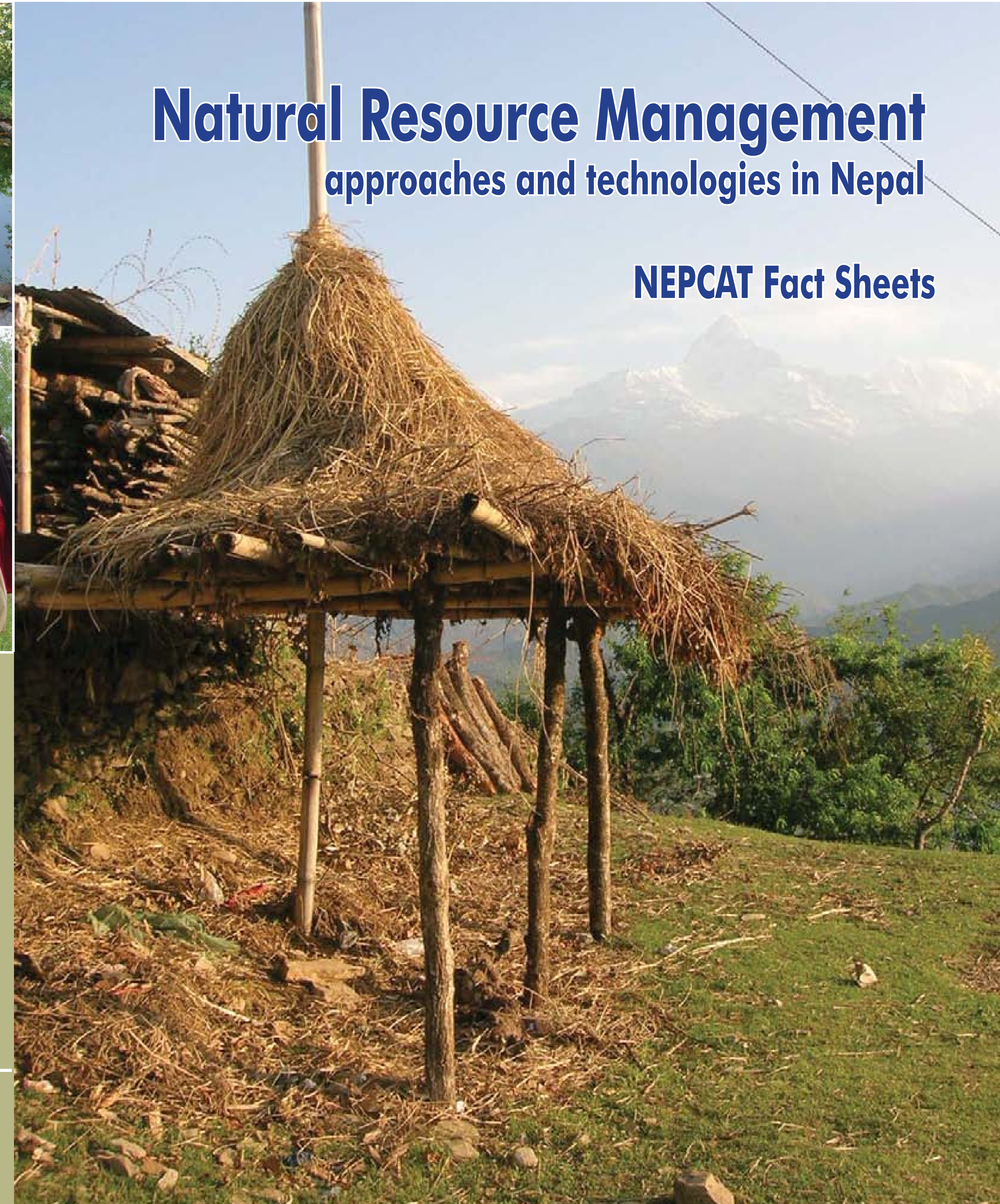
NEPCAT is a network of natural resource management specialists set up to facilitate the sharing of knowledge and experience on natural resource management especially in Nepal. It is a part of the larger Himalayan network: HIMCAT. Both operate under the global WOCAT network. NEPCAT is a growing network open to any interested organisations and professionals. The logos on this cover show the major partners as of early 2008.

ICIMOD helvetas Nepal intercooperation



Natural Resource Management
approaches and technologies in Nepal

NEPCAT Fact Sheets

NEPCAT – Nepal Conservation Approaches and Technologies

WOCAT, HIMCAT and NEPCAT

The World Overview of Conservation Approaches and Technologies (WOCAT) is a global network of soil and water conservation (SWC) specialists that facilitates the sharing of knowledge on soil and water management and the efficient use of existing know-how. The Himalayan Conservation Approaches and Technologies (HIMCAT) network is an offspring of the global WOCAT initiative – a virtual platform set up to enable its members and other SWC specialists from across Asia to share their information and knowledge on soil and water management. Nepal Conservation Approaches and Technologies (NEPCAT) was set up under HIMCAT in 2006 specifically as a platform for sharing experiences from Nepal on soil and water management and natural resource management in general. Contributors experiences are documented using the WOCAT tool, a format for recording information in a consistent and comparable manner for easy reference and understanding.

The NEPCAT Fact Sheets

The NEPCAT experiences are compiled in an electronic database. For easy reference, 30 technologies and approaches are now being published as fact sheets, in print form and on a CD-ROM, to facilitate sharing with a wider audience in Nepal and other countries with similar climatic conditions in the Himalayan region. It is hoped that this initiative will grow as other institutions contribute fact sheets on promising technologies and approaches they have worked on. The aim is to enlarge the basket of options for natural resource management and encourage growth of an open loose network of institutions and organisations in Nepal to share information on their experiences with different technologies and related approaches. It is hoped that these options will also include farmers' innovations and technologies based on indigenous knowledge.

The fact sheets are designed to support the efforts of rural development, especially in Nepal, and provide impetus and ideas for decision makers, development actors, and land users. Users are encouraged to print out, copy, and distribute in any form that facilitates sharing with farmers and others. and with other potential collaborators. All new contributions to the database and fact sheets are welcome. Please contact us and join the NEPCAT initiative.

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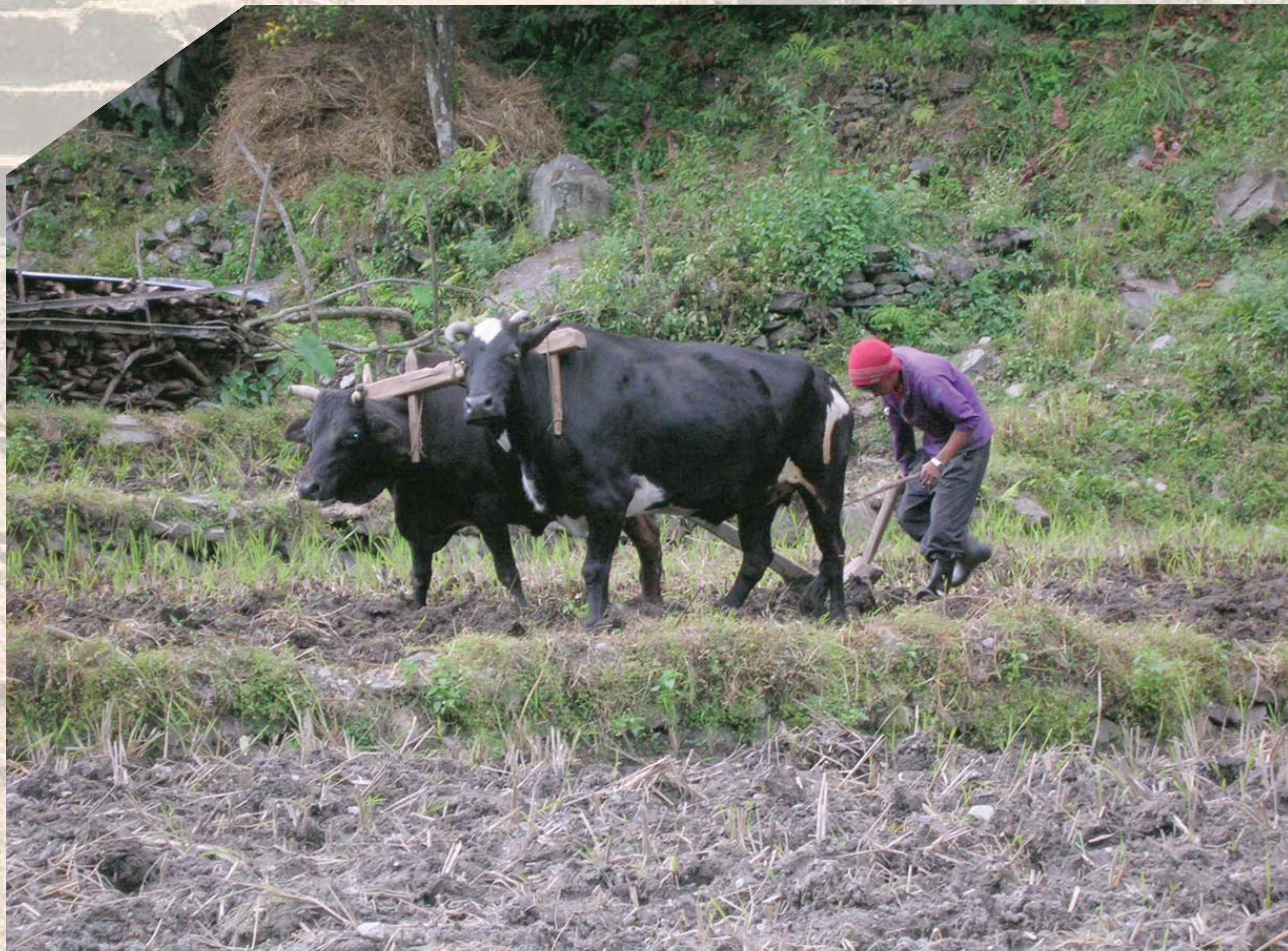
Lead partners

Sustainable Soil Management Programme (SSMP)

The Sustainable Soil Management Programme (SSMP) is funded by the Swiss Agency for Development and Cooperation (SDC) and implemented by Helvetas and Intercooperation in collaboration with participants from the government and civil society. The Programme contributes to improved food security and increased income of women and men farmers in bari-dominated (rainfed) farming systems in Nepal's mid hills. This is achieved by encouraging smallholders and disadvantaged groups to adopt sustainable soil management practices linked with improved production technologies and enabling them to seize new agricultural production opportunities. District extension services related to sustainable soil management are supported to respond better to the needs of smallholders and disadvantaged groups.

International Centre for Integrated Mountain Development (ICIMOD)

The International Centre for Integrated Mountain Development (ICIMOD) is an independent regional knowledge, learning and enabling centre serving the eight regional member countries of the Hindu Kush-Himalayas – Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan – and the global mountain community. Founded in 1983, ICIMOD is based in Kathmandu, Nepal, and brings together a partnership of regional member countries, partner institutions, and donors with a commitment for development action to secure a better future for the people and environment of the Hindu Kush-Himalayas. ICIMOD's activities are supported by its core programme donors: the Governments of Austria, Denmark, Germany, Netherlands, Norway, Switzerland, and its regional member countries, along with programme co-financing donors. The primary objective of the Centre is to promote the development of an economically and environmentally sound mountain ecosystem and to improve the living standards of mountain populations.



LIST OF SHEETS*

A) By Subject Area

B) By Database Number**

Approach

QA NEP 1 Farmer-to-farmer diffusion
QA NEP 2 Improving terraces with farmers
QA NEP 3 Farmer-led experimentation
QA NEP 4 Farmer field school on integrated plant nutrient systems
QA NEP 6 Participatory action research on drip irrigation
QA NEP 11 Integrated watershed management for landslip and stream bank stabilisation
QA NEP 13 Local initiatives for rehabilitating degraded communal grazing land
QA NEP 15 Evaluation of the system of rice intensification (SRI) through participatory research and development
QA NEP 17 Community efforts for improving drinking water quality

Technology

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QT NEP 2 Improved terraces
QT NEP 3 Legume integration
QT NEP 4 Organic pest management
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QT NEP 7 Improved compost preparation
QT NEP 8 Better quality farmyard manure through improved decomposition
QT NEP 9 Improved farmyard manure through sunlight, rain and runoff protection
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QT NEP 21 Low cost micro-sprinkler Irrigation
QT NEP 22 Plastic-lined conservation pond to store irrigation water
QT NEP 23 Cultivation of fodder and grasses
QT NEP 24 Urine application through drip irrigation for bitter gourd production

* Status April 2008 – NEPCAT is an open network of institutions and organisations in Nepal who wish to share information on their experiences and innovations. The NEPCAT fact sheet collection is open for new contributions and expected to grow in the future.
** Reference number in global WOCAT database QT = Technology; QA: Approach

Left: A demand farmer group observing a cauliflower field (Christoph Morger)
Right: An experienced lead farmer showing his protected farmyard manure heap (Juerg Merz)

Farmer-to-farmer diffusion

Nepal: किसान–किसान कृषि प्रसार

Wider diffusion of sustainable soil management technologies through a demand responsive farmer-to-farmer diffusion approach

The Sustainable Soil Management Programme (SSMP) is spreading knowledge about sustainable soil management technologies through farmer organisations and government and non-government partners. These collaborating institutions are working closely with lead farmers in training and technology testing. These farmers in turn work in close collaboration with their local groups. Although this approach is successfully diffusing new technologies from lead to group farmers, and on to nearby farmers, it remains a big challenge to diffuse the technologies further to the wider community.

To increase the spread of the technologies, SSMP pilot tested farmer-to-farmer (FtF) diffusion in eight midhills districts in 2002, later expanding to an additional five districts. Firstly, district based FtF extension committees were formed. Their major function is to select and train experienced lead farmers (ELF); to identify demand farmer groups; to facilitate contact and agreements between ELFs and demand farmer groups; to assess these agreements; to approve and channel funds to accepted proposals, and to monitor and evaluate the services provided. The demand farmer groups both propose the training events and select which of the currently 500 ELFs they want to lead their training. Demand farmer groups may be any group of farmers. Their proposals need to be recommended by a 'demand actor' such as a non-government or government organisation, a local authority, or a development project. Once a demand proposal is approved, the FtF extension committee provides funds to the demand group to pay the ELF and the other costs of the training.

Experienced lead farmers play a pivotal role in this process. They are generally progressive farmers with long farming experience who have good leadership and communication skills, are motivated to bring about change, and are interested in serving disadvantaged groups. They are trained on sustainable soil management technologies to enable them to provide training and follow-up to farmers groups outside the areas of collaborating institutions and to disseminate technologies which have proven to be appropriate and successful under local conditions.

The Sustainable Soil Management Programme (SSMP) implements its projects in several midhills districts of Nepal
(dark green: previous working districts;
light green: districts in 2007)

WOCAT database reference: QA NEP1
Location: Nepal
Land use: Cropland
Climate: Humid subtropical
Related technology: Improved cattle shed for urine collection (QT NEP1); Legume integration (QT NEP3); Organic pest management (QT NEP4); Improved compost preparation (QT NEP7), Better quality farmyard manure through improved decomposition (QT NEP8)' Improved farmyard manure through sunlight, rain and runoff protection (QT NEP9)' Cultivation of fodder and grasses (QT NEP23); Urine application through drip irrigation for bitter gourd production (QT NEP24)
Compiled by: SSMP
Date: May 2007

The Sustainable Soil Management Programme is implemented by Helvetas Nepal and Intercooperation in collaboration with the Government of Nepal and civil society actors. It is financed by the Swiss Agency for Development and Cooperation. The technology was documented using the WOCAT (www.wocat.org) tool.

Problem, objectives and constraints

Problem

The Nepal government's agricultural extension system was widely dysfunctional during the recent conflict (1996-2006). Many agricultural service centres were disbanded and were therefore unable to provide essential services to local farmers. Many farmers, especially in the remoter areas, had nowhere to turn for technical help with their agronomic problems, often resulting in lower yields and less income.

Objectives

- Provide agricultural extension services with a particular focus on sustainable soil management
- Builds up an extension system that is functional outside of central government structures
- Sustainable learning from local farmer to local farmer
- Cost effective service delivery

Constraints addressed

Major	Specification	Treatment
Technical	Soil fertility decline and soil degradation	Sustainable soil management technologies
Institutional	Dysfunctional government extension services	Farmer-to-farmer exchange and learning
Financial	Lack of money for technical support	Reliance on local human resources

Participation and decision making

Target groups

Land users

Approach costs met by:

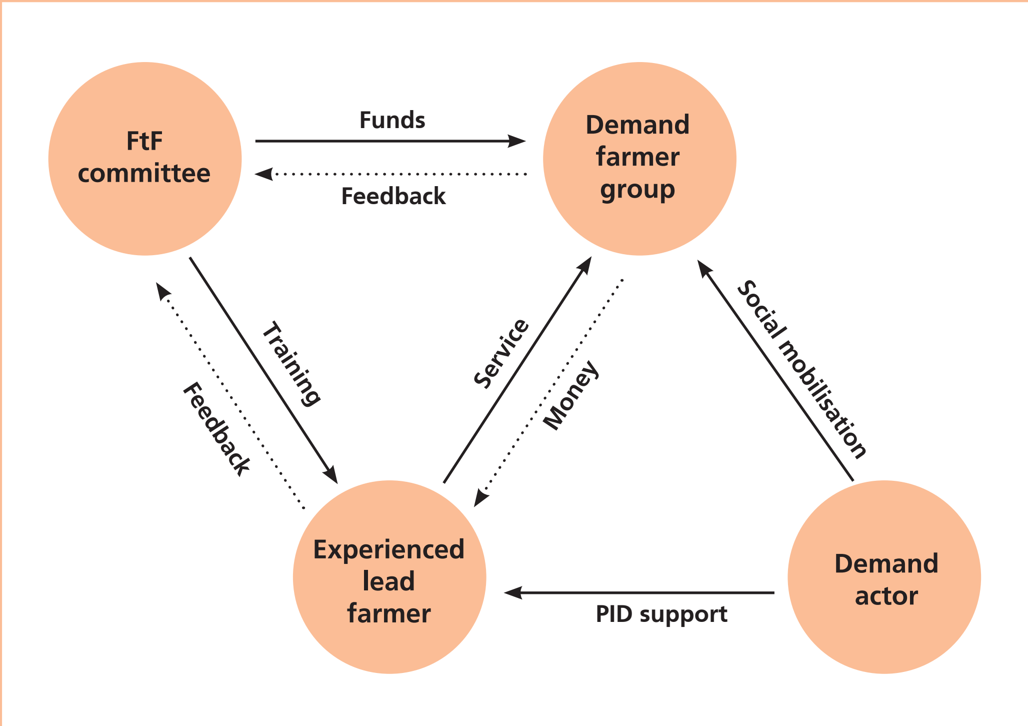
Development project (seeds, trainer)	50%
Farmers (labour, training costs)	50%
TOTAL	**100%**

Decisions on choice of the technologies: Made collectively by the demand farmer group and refined with assistance from experienced lead farmers. The main interest of demand farmer groups has been in farmyard manure management, legume integration, and vegetable production.
Decisions on method of implementing the technologies: Proposed by demand farmer groups with assistance from experienced lead farmers and endorsed by farmer-to-farmer committees
Approach designed by: Sustainable Soil Management Programme (SSMP) on the basis of experience from the literature and other projects of implementing agencies

Community involvement

Phase	Involvement	Activities
Initiation	Passive to interactive	Demand creation by demand actors and experienced lead farmers; in rare cases demand is created by demand farmer groups
Planning	Interactive	Preparation of demand proposals and submission to committee Proposal assessment by committee Selection of experienced lead farmer Fund disbursement to demand farmer group
Implementation	Interactive	Experienced lead farmer provides training in appropriate season on basic knowledge required The training is field based on the land of members of the demand farmer group The experienced lead farmer visits the demand farmer group two to three times after the training to provide follow-up and support
Monitoring/ evaluation	Interactive	The demand farmer group pay the experienced lead farmer once they are satisfied with the services provided (= direct monitoring by clients); training report by experienced lead farmers to farmer-to-farmer committees including proposing potential new ELFs from amongst trainees; end of training monitoring by local monitoring person on behalf of the farmer-to-farmer committee.
Research	-	-

Differences in participation of men and women: Farmer-to-farmer diffusion is equally suitable for men and women. Equal participation of women should be ensured in mixed farmer groups. To date, about 33% of experienced lead farmers and about 60% of the members of demand farmer groups have been women.



Organogram of the farmer-to-farmer diffusion process
The detailed process is described in the operational guidelines (Paudel et al. 2002).

The committee is made up of:
- chief of the district agricultural development office (DADO) as chairperson
- representative of a collaborating institution (member secretary)
- programme officer of the district development committee (DDC) (member)
- one male and one female reputed local farmer (members)
- livestock and extension experts from the district livestock and agriculture development offices (members).

PID = participatory innovation development

Extension and promotion

Training: Training on the farmer-to-farmer approach was provided to different demand actors including non-government and government organisations, by resource persons closely involved in designing the approach.
Extension: The approach has been accepted by the government's Ministry of Agriculture and Cooperatives as part of its Agricultural Extension Policy (2007). Phase 3 of the Sustainable Soil Management Programme (2008 to 2010) will further support the institutionalisation of the approach at the operational level.
Research: Not applicable
Importance of land use rights: Not important for the success of the approach: it is only important for the technology that is diffused with this approach

Incentives

Labour: Own labour
Inputs: New seed and non-local inputs for demonstration purpose are provided for one season
Credit: Not applicable
Support of local institutions: Support only to local farmers groups
Long-term impact of incentives: Incentives provided by the programme are for demonstration only. If the technology is suitable to their circumstances demand farmer groups need to manage the required inputs themselves.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Biophysical	suitability of the promoted technology
Technical	client satisfaction after the training
Socio-cultural	suitability of the promoted technology
Economic/production	suitability of the promoted technology
Area treated	none
No. of land users involved	regular recording of attendance during meetings/trainings/follow-up
Management of approach	monitoring of expenses; demand assessment

Impacts of the approach

Changes as a result of monitoring and evaluation: Regular monitoring and impact assessments have led to the continuous adaptation of the approach and its norms.
Improved soil and water management: Depends on the technology diffused to the group through this approach
Adoption of the approach by other projects/land users: The approach has been included in the government's Agricultural Extension Policy (2007); although it still needs to be implemented. In some districts, other development partners have expressed an interest in supporting this approach with their funds.
Sustainability: The approach is locally based and decisions are made by local institutions and farmers themselves. At present the approach is mainly financially supported by a development project with efforts being made to obtain more sustainable funding from local authorities, registered community groups (e.g. forestry, irrigation), and farmers groups' savings.

Concluding statements

Strengths and ➔how to sustain/improve	Weaknesses and ➔how to overcome
Both the service provider and the demand groups are local farmers; this programme therefore directly benefits only the local farming community	Very small project agreements; wide scattered geographic area coverage; many proposals and difficulties in financial management and monitoring ➔ operational guidelines need to be reviewed
The service providers are directly accountable to the farmer clients, in contrast to using government and NGO extension workers who are only accountable to their institutions	The success of the programme depends mainly on the abilities and knowledge of the experienced leader farmers ➔ need to put more focus on selecting appropriate candidate ELFs and better training them and more extensively exposing them to new technologies
Builds on farmers' field experience and communicates the technology through farmers' own words/terminology rather than through more technical extension messages from scientists	The facilitation from demand actors for this process is important; but they are reluctant to do this since the institutions do not financially benefit from the process
More cost-effective for wider dissemination in comparison with other extension systems	Experienced leader farmers are reluctant to do paper work like filling in agreement proposal forms, maintaining a diary and preparing lesson plans
Especially effective in heterogeneous environments amongst non-literate farm communities	Difficulties in identifying demand groups according to the expertise of experienced lead farmers ➔ increase awareness of the approach in rural areas through a comprehensive dissemination strategy using all media
Technologies adopted through farmer-to-farmer diffusion are likely to be more stable and sustainable because experienced leader farmers will only disseminate successful technologies	Farmers' interest is mainly on technologies that are profitable in the short term and less on long term sustainable soil management ➔ expand the farmer-to-farmer diffusion process to other topics and subjects as a part of agricultural extension
This approach may carry messages and content on subjects other than sustainable soil management ➔ institutionalise the approach as a general grass roots-based extension approach	Financial support for the programme at present comes from a development project and will end when the project ends ➔ efforts need to be made to institutionalise the approach and seek out local sources of funding

Key reference(s): Paudel, C.L.; Kafle, B. R.; Bajracharya, B. (2007) *Training Manual on Farmer-To-Farmer Diffusion Process for Sustainable Soil Management Practices in Nepal* (in Nepali). Kathmandu: Sustainable Soil Management Programme ■ Paudel, C.L.; Regmi, B.D.; Schulz, S. (2005) 'Participatory Innovation Development – Experiences of the Sustainable Soil Management Programme in Nepal.' In Kolff, A.; van Veldhuizen, L.; Wettasinha, C. (eds) *Farmer Centred Innovation Development – Experiences and Challenges from South Asia,* pp. 109-126. Bern: Intercooperation
Contact person(s): Director, Soil Management Directorate, Department of Agriculture, Harihar Bhawan, Lalitpur, +977 1 5520314 or
Team Leader, Sustainable Soil Management Programme (SSMP), GPO Box 688, Kathmandu/Nepal, +977 1 5543591, ssmp@helvetas.org.np

Left: A farmer-technician interaction programme; holding such programmes before implementing new technologies builds farmer's confidence in the technology. (PARDYP)
Right: A farmer exchange programme underway – an important scaling-up approach. (PARDYP)

Improving terraces with farmers

Nepal: किसानसंगै गह्रा सुधार

Participatory action research with multiple stakeholders for the demonstration and extension of improved rainfed hill terraces in Nepal

The traditional farming practices employed on steep sloping land in Kubinde village in Nepal's midhills led to soil and water erosion and low crop and fodder yields. The People and Resource Dynamics in Mountain Watersheds of the Hindu Kush-Himalayas Project (PARDYP) started work in 2001, with a small group of farmers from this village (who were also members of the local forest user group) and the Department of Soil Conservation and Watershed Management to identify and test an integrated approach for addressing these constraints. The approach taken was an improved hill terrace for rainfed conditions consisting of structural and vegetative measures.

The aim was to demonstrate and test the technologies' potential for overcoming constraints related to farming sloping agricultural land. The specific objectives were, in association with the local farmers, to design a technology that solved soil erosion problems on sloping agricultural lands whilst at the same time increasing the land's nutrient conservation and production capacity. The local line agency office of the Department of Soil Conservation and Watershed Management was involved in developing the technology to make use of their experiences and to come up with a validated technology that the department could use in its own programmes.

Before implementing the terrace improvement work in Kubinde village, a terrace improvement committee was formed made up of local farmers. The awareness activities began in January 2001. Committee members were trained on sub-watershed management and were taken to the International Centre for Integrated Mountain Development's (ICIMOD) Demonstration and Training Centre at Godavari and another ICIMOD site to show them potential soil and water conservation technologies including improved terraces.

After the technologies were implemented, a number of farmer exchange, interaction and monitoring programmes were held to assess the technology and to promote it. Indicators were developed for monitoring the activity.

About half of the costs were covered by the participating farmers and the rest by PARDYP. The other incentives were training and extension, allowances for participants, national expert honoraria, and training material such as audio-visual facilities. These were all provided by PARDYP with the help of the line agency.

WOCAT database reference: QA NEP2
Location: Kubinde village, Jhikhu Khola watershed, Kabhrepalanchok district, Nepal
Approach area: 0.02 km^2
Land use: Annual cropping
Climate: Humid subtropical
Related technology: Improved terraces, QT NEP2
Compiled by: Madhav Dhakal, ICIMOD
Date: February 2003, updated May 2007

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

Problem, objectives and constraints

Problem

- Weak institutional collaboration for addressing 1) poor soil fertility and land productivity; 2) soil and nutrient loss and excessive water runoff from sloping agricultural land; and 3) fodder scarcity.
- Lack of on-farm research for developing technologies that attend to farmers' needs.

Objectives

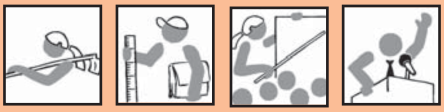
- Local farmers collectively solving problems by identifying and using the most appropriate local solutions
- Local farmers designing, testing, and disseminating alternative technologies adapted to local conditions
- Strengthening joint learning by farmers and development actors

Constraints addressed

Major	Specification	Treatment
Technical	Not a priority area of line agencies	The approach relies on farmer adoption
Institutional	Lack of coordination among land users	Terrace improvement user group formed
Minor	**Specification**	**Treatment**
Financial	Government incentives are lacking	The technology is cost-effective
Other	Lack of awareness	Trainings, discussions, and field visits

Participation and decision making

Target groups



Land users — Extension workers — School teachers and children — Local leaders

Approach costs met by:

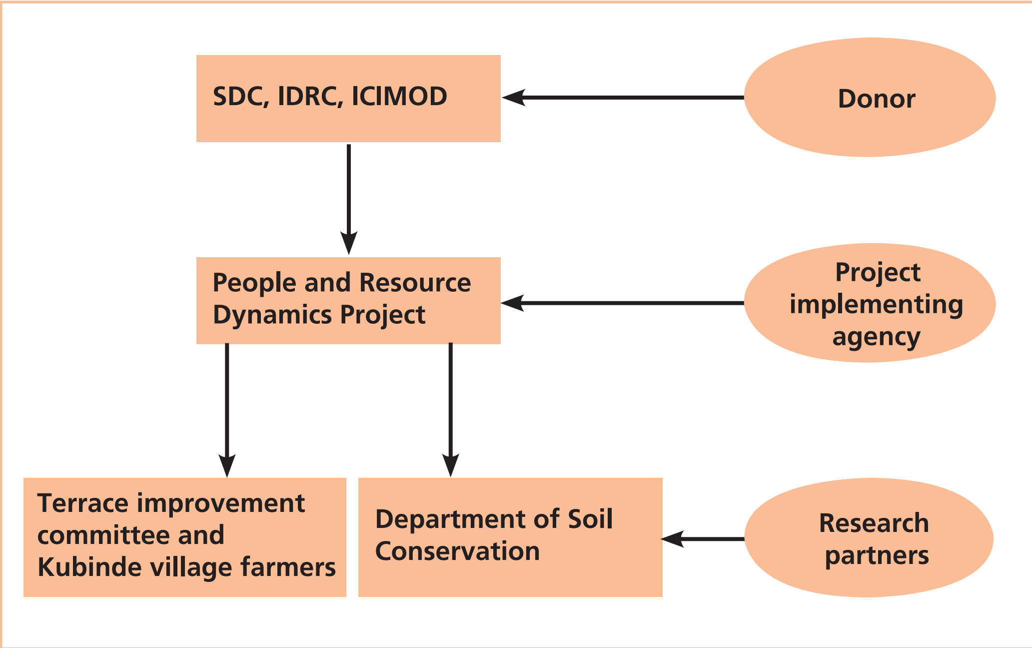
International donor funded project (PARDP)	65%
Community/local	35%
TOTAL	**100%**

Decisions on choice of the technology: Mainly national soil and water conservation (SWC) specialists in consultation with land users. The package was initially offered by researchers and later modified and implemented by land users.
Decisions on method of implementing the technology: Mainly land users supported by national SWC specialist as land users are more familiar with their land's capacity and characteristics.
Approach designed by: Designed by national specialist together with district soil conservation office. The implementation approach was jointly designed by the specialist and land users.

Community involvement

Phase	Involvement	Activities
Initiation	Passive	Group discussions organised with local forest user group; selection of members for training tours (12 men and 11 women); formation of terrace improvement committee
Planning	Interactive	Survey, site selection, fodder/grass species selection
Implementation	Self-mobilisation	Terracing activities: measurement, soil excavation, and retaining wall construction
Monitoring/ evaluation	Interactive	Done in a participatory way involving individual farmers, project staff, and Department of Soil Conservation staff
Research	Passive	Assessing performance of planted grasses and advantages and disadvantages of technology

Differences in participation of men and women: None as both participated equally



Project donors and implementing partners
SDC: Swiss Agency for Development and Cooperation
IDRC: International Development Research Centre
ICIMOD: International Centre for Integrated Mountain Development

Extension and promotion

Training: Before implementing the technology, a training on sub-watershed management was provided to local land users including women, school teachers and students, and local leaders. The training was based around visits to farms and demonstration sites and used information, education, and communication materials including a film on watershed management. The training was very effective as all participants learned much about the benefits of soil and water conservation.
Extension: After the implementation of the technology, a number of exchange, interaction, and monitoring programmes were held as a scaling up strategy. The involvement of multiple stakeholders in these programmes helped to evaluate the technology.
Research: Some ad hoc research has been carried out on the impacts of the technology and the performance of the structures and vegetation.
Importance of land use rights: Individual land use rights helped to implement the technology as there were no conflicts among land users.

Incentives

Labour: About 50% of total labour costs were met by land users.
Inputs: PARDYP provided grass seeds and seedlings free of charge, and fruit trees (papaya) were provided once.
Credit: No credit was provided.
Support of local institutions: None
Long-term impact of incentives: The incentives for implementing the technology helped improve the sloping land by creating awareness about SWC. As a result, land users converted many sloping fields into level terraces without any external help. Incentives had a great positive long-term impact.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Biophysical	ad hoc observations on plant height, biomass production, and usefulness of fodder/grass species
Technical	ad hoc observations by SWC experts for providing their views about the technology
Socio-cultural	ad hoc observation on farmers' preferences in terms of species selection and on how farmers change their agricultural practices
Economic / production	ad hoc observations on changes in crop yields and patterns and the value of the land
Area treated	ad hoc observations through farmer survey and on-site verification of results
No. of land users involved	ad hoc observations through farmer survey on number of land users applying the SWC technology
Management of appraoch	ad hoc observations on how farmers maintain their terraces and the hedgerows

Impacts of the approach

Changes as result of monitoring and evaluation: New ideas have been generated but strategies to implement them have yet to be put in place.
Improved soil and water management: Area expanded about 100% from 2001 to 2003. New varieties of grass and fodder species have been introduced.
Adoption of the approach by other projects/land users: The project's aim was not to promote the approach but the technology. Similar approaches have been followed by other departments and programmes such as the District Soil Conservation Office.
Sustainability: More than 60% of the total improved terraces in Kubinde village were built by the land users themselves. Widespread rapid adoption did not happen in other villages due to financial and labour limitations. Land users of Kubinde village continue to maintain the improved terraces.

Concluding statements

Strengths and ➔how to sustain/improve*	Weaknesses and ➔how to overcome
The approach is based on building the capacity of farmers (both men and women) by involving multiple stakeholders in the development and adoption of the technology ➔ Approach should be to strengthen land users' involvement in SWC activities	Due to the conflict, which was on-going at the time, follow-up after a year of implementing technology was not possible and the monitoring was not done. This resulted in the adoption of the technology by other farmers not being carried out properly with, for example, farmers not maintaining the hedgerows as recommended. Also, the new terraces were not as good as they should have been. ➔ The technical experts need to visit the sites and identify gaps and encourage farmers to 'fill them'. For example, the benefit of hedgerow management needs to be demonstrated
Technical knowledge and confidence increased from the training and field visits, interactions, and experience sharing ➔ Such activities should be continued by incorporating other new ideas	
The approach led to the development of a team spirit among farmers ➔As above	

Key reference(s): Mathema, P. (2003) *Watershed Management in South Asia.* Kathmandu: Government of Nepal, Department of Soil Conservation and Watershed Management
Contact person(s): HIMCAT/WOCAT Coordinator, International Centre for Integrated Mountain Development (ICIMOD), GPO Box. 3226, Kathmandu, Nepal, himcat@icimod.org

Left: Initial discussions about farmer-led experimentation with a farmers' group (Neema Joshi)
Right: Farmer-led experimentation on different cauliflower varieties (Juerg Merz)

Farmer-led experimentation

Nepal: कृषकले गर्ने परीक्षण वा कृषकको अगुवाइमा गरिने परीक्षण

Participatory technology testing and adaptation through farmer-led experiments

Farmer-led experimentation is a type of action research initiated and carried out by farmers in their own fields. This approach enables farmers to identify technological options suited to local agroecological and socioeconomic conditions. The farmer-led experimentation process is taken up within existing farmer groups. This approach is closely related to the 'participatory innovation development' and the 'participatory technology development' approaches as discussed in Kolff et al. (2005).

Simple experiments are usually replicated in five to ten farmers' fields per group. Generally, the whole of each experimental plot from each field is harvested and the yield recorded. Field implementation, group visits, and observations are carried out by the farmers themselves. The processing of results is done in groups together with the support staff from the facilitating organisation. These farmers are very likely to adopt tested technologies that are shown to be better for meeting their needs. The results are also used by support staff and shared with other organisations, and provide input for dissemination through farmer-to-farmer diffusion.

Farmers play a leading role in all steps of the process, starting from problem identification to planning, implementation, and evaluation of the experiments. This ensures that farmers are the driving force in the research process and not mere recipients of research findings that have been generated elsewhere. The detailed implementation plan is discussed within the groups and individual and collective responsibilities are assigned. The experimental site, individual implementing farmers, group visits, and results-sharing meetings are decided on by group consensus. Some observations are recorded by the implementing farmers. Promising innovations are then identified based on the collective evaluation of the tested treatments. Technical and other facilitation support is provided by organisations active in the area.

The Sustainable Soil Management Programme (SSMP) implements its projects in several midhills districts of Nepal
(dark green - previous working districts; light green - districts in 2007)

WOCAT database reference: QA NEP3
Location: Nepal
Land use: Cropland
Climate: Humid subtropical
Related technology: Improved cattle shed for urine collection (QT NEP1); Legume integration (QT NEP3); Organic pest management (QT NEP4); Improved compost preparation (QT NEP7); Better quality farmyard manure through improved decomposition (QT NEP8); Improved farmyard manure through sunlight, rain and runoff protection (QT NEP9); Cultivation of fodder and grasses (QT NEP23); Urine application through drip irrigation for bitter gourd production (QT NEP24)
Compiled by: SSMP
Date: May 2007

The Sustainable Soil Management Programme is implemented by Helvetas Nepal and Intercooperation in collaboration with the Government of Nepal and civil society actors. It is financed by the Swiss Agency for Development and Cooperation. The technology was documented using the WOCAT (www.wocat.org) tool.

Problem, objectives and constraints

Problem
- The common issues concerning farmers in growing crops include pests and diseases, yield decline, inappropriate crop varieties, and the introduction of new varieties. Rather than technicians providing farmers with ready-made solutions to their problems (that may or may not work), farmer-led experimentation allows farmers to carry out their own trials to try and solve specific problems.

Objectives
- Local farmers collectively solving problems by identifying and using the most appropriate local solutions
- Local farmers designing, testing and disseminating alternative technologies adapted to local conditions
- Strengthening joint learning by farmers and development actors

Constraints addressed

Major	Specification	Treatment
Technical	Problems related to agricultural production and soil fertility	Testing and adaptation of technologies to local conditions using local human and natural resources
Institutional	Dysfunctional government extension system	Reliance on local human resources and farmer to farmer collaboration
Financial	Lack of money for technical support	Collaborative approach amongst farmers from the same settlements

Participation and decision making

Target groups


Land users

Approach costs met by:

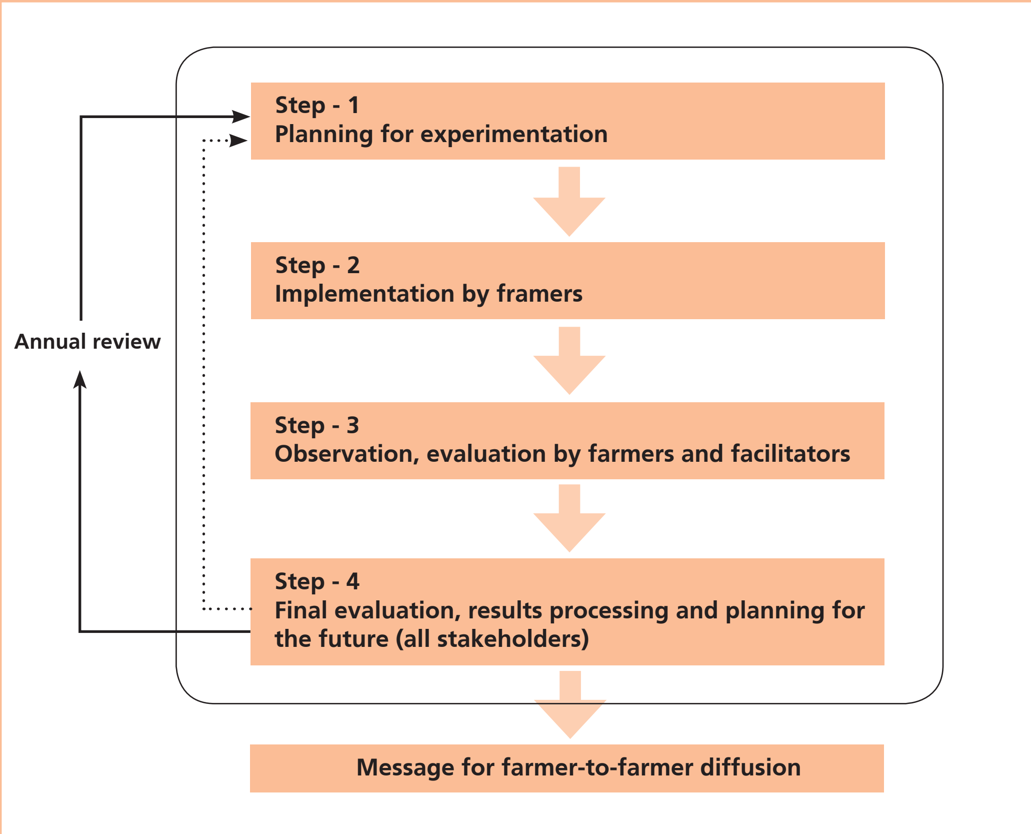
Development project (inputs, external resources)	50%
Farmers group (local resources, labour, land)	50%
TOTAL	**100%**

Decisions on choice of the technology: Made collectively by farmers in group facilitated by organisation working with them
Decisions on method of implementing the technology: Made by farmers in group
Approach designed by: Sustainable Soil Management Programme (SSMP) on the basis of experiences from the literature and implementing other agencies' projects

Community involvement

Phase	Involvement	Activities
Planning	Interactive: participatory discussions and exercises, field visits, farm maps, farming and labour calendar	Identification of topics for experiment based on needs and priority Identification of technological options (indigenous and external) Farmers developing simple and appropriate experiments Decision on management approach (overall management of experiment, implementing, recording, disseminating) Action plan development by farmers Record-keeping sheet designed by farmers Identification of technological successes, seed sources Commitments and assignment of responsibilities
Implementation	Interactive: follow-up visits, discussions	Farmers implement according to the design for comparison with a control (= existing practice) Farmers note relevant observations on recording sheet Farmers note other important observations based on their needs and interests Technical support and discussions with farmers during follow-up visits Farmers discuss performance/experiences from trial and seek outside support if there is any problem
Monitoring/ evaluation	Interactive: field visit to experimental site by other farmers, participatory discussion and evaluation	Experimenting farmers and other farmers jointly discuss and evaluate based on direct observations of the trial and from the record sheet Discussion on the lessons learned and identifying possible modifications to overcome identified problems Discussion on the promotional aspect of the technology if it is found appropriate
Research	-	-

Differences in participation of men and women: Farmer-led experimentation is equally suitable for both men and women. However, if farmers groups are mixed, an eye has to be kept on the equal participation of both genders.



Organogram of farmer-led experimentation
This approach has four key stages:

1) planning
2) implementation
3) observation
4) final evaluation

If promising results come from the experimentation, the message can be further diffused to other farmers in the area through farmer-to-farmer diffusion (QA NEP1). If results are not suitable, a new farmer-led experiment can be planned with an improved layout.

Extension and promotion

Training: Initially training was provided to staff from collaborating institutions and lead farmers on how to carry out farmer-led experimentation, explaining its principles and its practical application.
Extension: Implementation and field coaching is done by local resource persons together with farmers. Observation and data recording is jointly done by implementing farmers and staff of the collaborating institutions. First, the results are shared and discussed with group members. Sound results that are supported by the group members are then shared with a wider audience at the project's quarterly district meetings The District Agricultural Development Office and the Nepal Agricultural Research Council's regional research stations are invited to monitor and evaluate the experiments and learn from them for wider diffusion in other parts of the district and the region.
Research: Various options for addressing farmers' crop growing problems are tested and the results compared with existing practices. No basic research is done with this approach.
Importance of land use rights: The trials are carried out on privately owned land. For groups with a good common understanding, experiments could also be conducted on community land.

Incentives

Labour: Participating farmers
Inputs: Provided by the project for testing purposes
Credit: Not applicable
Support of local institutions: Technical support provided by project
Long-term impact of incentives: Where a technology is perceived to be suitable and applicable, incentives have not hindered its adoption except where large investments are needed such as for improving cattle sheds (see technology fact sheet on urine collection (QT NEP1)

Monitoring and evaluation

Monitored aspects	Methods and indicators
Biophysical	informal farmer observations only
Technical	informal farmer observations only
Sociocultural	not applicable
Economic / production	informal farmer observations only
Area treated	informal farmer observations only
No. of land users involved	informal farmer observations only
Management of appraoch	informal farmer observations only

Impacts of the approach

Changes as a result of monitoring and evaluation: The adoption of certain technologies has occurred as a result of farmer-led experimentation. For example, a farmer-led trial of two varieties of groundnut (local and B4), in Ghadgaon, Surkhet, led to farmers starting to grow the B4 variety in an area where previously only local varieties had been grown. The adopting farmers saw the benefit of planting the new variety (higher yield, easier to harvest) and are convinced they will earn more profits from growing it. Other examples, such as farmer-led experiments comparing the results of applying urea or cattle urine as fertilisers, and comparing of traditional versus improved farmyard manure have demonstrated the advantages of using the new technique.

Improved soil and water management: Great impacts on soil fertility and yields have been reported after the adoption of sustainable soil management tested through farmer-led experimentation.

Adoption of the approach by other projects/land users: Several farmers in the project area have started to do farmer-led experiments on their own, including on intercropping different vegetables and spices, and on urine application through drip irrigation.

Sustainability: As mentioned above, some farmers are implementing the approach on their own initiative. This is possible because of the low costs and limited technical requirements of the approach. Farmers exposed to the approach will be able to apply the approach again to problems that arise in their fields without the need to consult outside agencies.

Concluding statements

Strengths and ➔how to sustain/improve	Weaknesses and ➔how to overcome
Experiments are conducted on the basis of farmers' priorities and according to local conditions. This means that farmers develop ownership of the experiments and the derived results.	Experiments are not carried out in a scientifically rigorous way and therefore only have limited scientific value for evaluating technologies. ➔ if scientific proof is required, farmer-led experiments should be closely supported by technicians (per se not a farmer-led experiment anymore!)
Once farmers are exposed to the approach, they can apply it on their own initiative. This is possible because of the low costs and technical requirements of the approach.	Documentation of the activities and results for wider sharing is often poor and inadequate ➔ clear guidelines are needed for documentation with clear instructions on what, when, and how to record important information. This is necessary so that the results can be more widely used.
The approach serves both as a local test for suitability and adaptation potential as well as for demonstrating an already tested technology.	In some cases a lack of research equipment for better documentation and observation inhibits better understanding.

Key reference(s): Paudel, C.L.; Regmi, B.D.; Schulz, S. (2005) 'Participatory Innovation Development – Experiences of the Sustainable Soil Management Programme in Nepal.' In Kolff, A.; van Veldhuizen, L.; Wettasinha, C. (eds) *Farmer-centred Innovation Development – Experiences and Challenges from South Asia*, pp. 109-126. Bern: Intercooperation ■ SSMP (2001) *Implementation Guideline on Farmer Led Experimentation* (in Nepali). Kathmandu: Sustainable Soil Management Programme

Contact person(s): Director, Soil Management Directorate, Department of Agriculture, Harihar Bhawan, Lalitpur, +977 1 5520314 or
Team Leader, Sustainable Soil Management Programme (SSMP), GPO Box 688, Kathmandu/Nepal, +977 1 5543591, ssmp@helvetas.org.np

Left: Farmers observing a cauliflower plot during a regular farmer field school session (Steffen Schulz)
Right: Participants in a farmers' training of trainers-group work on nutrient calculation (Basu Dev Regmi)

Farmer field schools on integrated plant nutrient systems

Nepal: कृषक पाठशाला

Participatory and collaborative learning through the farmer field school approach

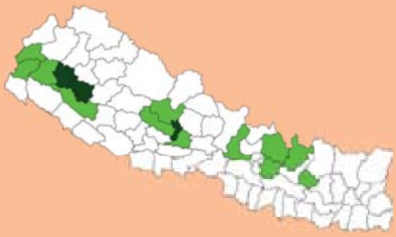
There are different ways of carrying out agricultural extension. Farmer field schools represent a participatory approach that directly reaches farmers and addresses their day-to-day problems. The concept of farmer field schools builds on the belief that farmers are the main source of knowledge and experience in carrying out farm operations, in contrast to conventional top-down approaches that place most value on scientists' findings.

The term 'farmer field schools' came from the Indonesian expression 'sekolah lapangan' which means 'field school'. It is a group based learning approach, which brings together concepts and method of agro-ecology, experiential education, and community development. The first field schools were established in 1989 in central Java when 50 plant protection officers tested and developed field training methods as part of an integrated pest management (IPM) training of trainers course. Two hundred field schools were established in that season involving 5,000 farmers. The following season, in 1990, an additional 45,000 farmers joined field schools run by 450 crop protection officers.

The same approach is being used in Nepal's integrated pest management programme. Several consultation meetings and workshops were held at national level to put the integrated nutrient management concept into practice. These meetings led to farmer field schools being recognised as an appropriate approach for putting this concept into practice. The approach was piloted in 2000 and 2001 and fully initiated in 2002 when 32 farmer field schools were run with support from SSMP. As far as SSMP knows, farmer field schools on integrated plant nutrient systems have been run since SSMP's involvement. The Government of Nepal's National Fertiliser Policy now recognises integrated plant nutrient systems as a concept to improve the efficient use of different nutrient inputs, and farmer field schools as an appropriate technology and extension approach for soil and plant nutrient management in Nepal.

So far some 226 farmer field schools have been run in Nepal on integrated plant nutrient systems reaching more than 5,000 households.

The Sustainable Soil Management Programme (SSMP) implements its projects in several midhills districts of Nepal
(dark green: previous working districts;
light green: districts in 2007)



WOCAT database reference: QA NEP4
Location: Nepal
Land use: Cropland
Climate: Humid subtropical
Related technology: Improved cattle shed for urine collection (QT NEP1); Legume integration (QT NEP3); Organic pest management (QT NEP4); Improved compost preparation (QT NEP7); Better quality farmyard manure through improved decomposition (QT NEP8); Improved farmyard manure through sunlight, rain and runoff protection (QT NEP9); Cultivation of fodder and grasses (QT NEP23); Urine application through drip irrigation for bitter gourd production (QT NEP24)
Compiled by: SSMP
Date: June 2007

The Sustainable Soil Management Programme is implemented by Helvetas Nepal and Intercooperation in collaboration with the Government of Nepal and civil society actors. It is financed by the Swiss Agency for Development and Cooperation. The technology was documented using the WOCAT (www.wocat.org) tool.

Problem, objectives and constraints

Problem

- Lack of effective and efficient ways of transferring technologies to farmers
- Conventional approach of technology transfer, where farmers are believed to have poor knowledge and skills
- Farmers are always perceived as a recipient of technology and knowledge

Objectives

- Transfer of technology to farmers on soil and plant nutrition management
- Empowerment of farmers
- Production of healthy crops without negative environmental effects

Constraints addressed

Extension	Top-down, technology-centred, not farmer-centred
Technical	Soil-fertility management, plant nutrient dynamics
Group	Unintegrated, less-organised group

Participation and decision making

Target groups


Land users


SWC specialists/ extensionists

Approach costs met by:

Development project	80%
Participants	20%
TOTAL	**100%**

Decisions on choice of the technology: In Nepal under the SSMP, farmer field schools have only been implemented to 'teach' integrated plant nutrient systems, there is no choice of technology

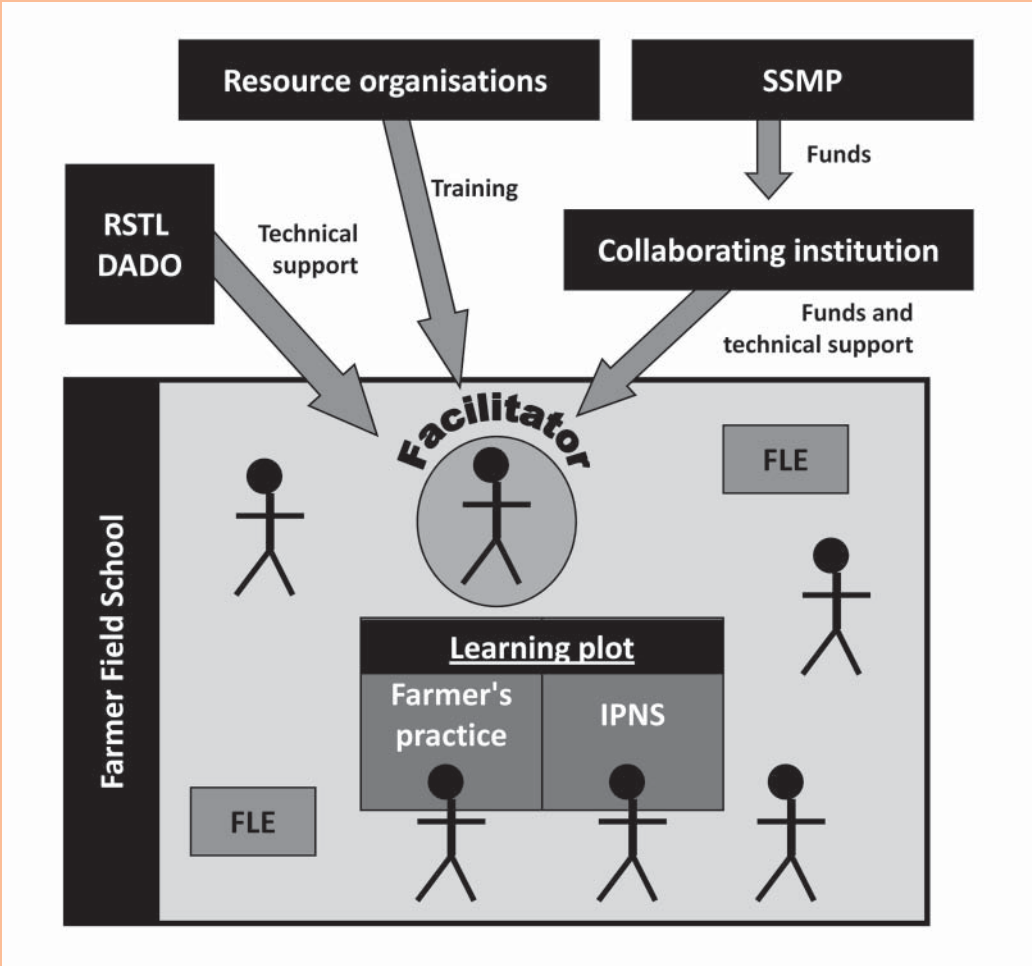
Decisions on method of implementing the technology: The curriculum for the farmer field school was developed by SSMP and the Government's Soil Management Directorate

Approach designed by: National and international specialists on soil and plant nutrient management

Community involvement

Phase	Involvement	Activities
Initiation	Interactive	Participatory approach: group discussions involving all local stakeholders
Planning	Interactive	Orientation workshop involving all stakeholders – farmers participation is crucial
Implementation	Interactive	Farmers are the key actors with trained staff of collaborating institutions (CI) facilitating the process
Monitoring/ evaluation	Interactive	Farmers evaluate and monitor jointly on a regular basis
Research	Adaptive research	Farmer-led experimentation based on local needs and context

Differences in participation of men and women: A majority of participants (>60%) were women farmers.



Organogram
Farmer field schools are usually facilitated by a field staff member of a collaborating institution and funded by SSMP. The facilitators are supported technically by the regional soil testing laboratories, district agricultural development offices, and the collaborating institution responsible for running the school. The facilitators are trained by a resource organisation.

A farmer field school is based on a learning plot divided into an area managed according to a typical farmer's practice and a plot managed according to the principles of integrated plant nutrient systems. Occasionally farmer-led experiments are run to evaluate different options.

SSMP = Sustainable Soil Management Programme
RSTL = regional soil testing laboratory, DADO = district agricultural development office,
FLE = farmer led experimentation,
IPNS = integrated plant nutrient system

Extension and promotion

Training: A training of trainers course is provided to selected staff from the collaborating institutions who have been involved substantially in agriculture development and farming practices activities. Seven days basic training on integrated plant nutrient systems and farmer field schools is provided. There is provision for a sharing forum at district level based on the demand of staff involved in conducting the farmer field schools. At these meetings, staff exchange their learning and experiences amongst each other and with the district agricultural development offices and the regional soil testing laboratories, These two organisations provide backstopping for technical matters.
Learning plot or extension: Learning plots (demonstration plots) are established in consultation and agreement with participating farmers. These plots are divided into two with the local farmer's practice on one side and the integrated plant nutrient system practice on the other. Farmers meet regularly and observe and analyse the differences between the two sides of the plots, identify problems that arise, and propose solutions. In this way, farmers learn in a participatory way and, as a result, are more likely to adopt what they learn in their fields.
Component trial/farmer led experiment: It is difficult to compare results if many treatments are applied at the same time in a plot. Therefore, it is always advised that component trials are run for different treatments. Such trials make for easier understanding of the different treatments and enable farmers to see the effects of particular treatments.
Support of local institutions: Local level organisations are involved in carrying out the farmer field schools. Local institutions are supported financially and technically by SSMP. The major aim of this approach is to build local level capacity.
Long-term impact of incentives: Building the capacity of farmers on healthy crop production and environment conservation, soil and crop productivity is enhanced through judicious use of local and external resources.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Biophysical	measurements (nitrate, nitrogen, pH, organic matter, P and K), crop measurements including yield
Technical	regular observations
Socio-cultural	regular observations of status
Economic/production	regular observations of cash income
No. of land users involved	20-30 farmers
Management of approach	participatory

Impacts of the approach

Capacity building of farmers: Through regular meetings and participatory discussions, farmers become used to speaking with other farmers about what they have learned. Regular observations and record keeping enhance farmers' analytical capabilities. Post evaluations of farmer field schools show that most farmers learn much from the schools including learning about group dynamics and developing presentation skills.

Improved soil and crop productivity: Attendance at farmer field schools has led to many farmers adopting practices that have improved the fertility status of their soils and have increased crop productivity. Most of these farmers have realised the need for the judicious use of local and external resources to increase crop production and conserve the environment.

Sustainability: Capacity remains at the local level so that farmers are able to run farmer field schools themselves.

Concluding statements

Strengths and ➔how to sustain/improve	Weaknesses and ➔how to overcome
Farmers are the source of knowledge; farmers adopt technologies based on their context ➔ Involve farmers in a more participatory way	Farmer field schools need time and their costs are higher than other similar approaches
Participatory approach	Non-technical staff are often involved in carrying out farmer field schools ➔ Ensure capacity building and regular sharing forums
Farmers decide the pace of implementation and what should be done	
The schools stress the importance of using local resources to reduce dependency on external resources	
Increased efficiency and effectiveness of local resources use	

Key reference(s): Paudel, C.L.; Regmi, B.D.; Schulz, S. (2005) 'Participatory Innovation Development – Experiences of the Sustainable Soil Management Programme in Nepal.' In Kolff, A.; van Veldhuizen, L.; Wettasinha, C. (eds) *Farmer Centred Innovation Development – Experiences and Challenges from South Asia,* pp. 109-126. Bern: Intercooperation ■ SSMP (2003) *Introduction to Integrated Plant Nutrient Systems* (in Nepali). Kathmandu: Sustainable Soil Management Programme

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Left: On-farm demonstration and exchange visits: women demonstrating the system to visitors (PARDYP)
Right: Farmer interaction programme: results and experiences were shared regularly through interaction meetings where drip users and non-users discussed the technology (Madhav Dhakal)

Participatory action research on drip irrigation

Nepal: थोपा सिंचाईमा सहभागीमूलक कार्यसंगै अनुसन्धान

Conducting participatory action research with farmers and line agencies for demonstrating, disseminating and scaling up drip irrigation

Most farming in the uplands of Nepal's midhills is rainfed with many fields remaining fallow during the dry season due to lack of irrigation water. The People and Resource Dynamics Project (PARDYP) water demand and supply survey identified scarcity of irrigation water as a major issue in Nepal's midhills. To assess the potential of drip irrigation to address this problem, the University of British Columbia (UBC) in 2000/2001, in collaboration with PARDYP, tested a low cost irrigation drip set and a more costly set in the Jhikhu Khola watershed; and PARDYP and Tribhuvan University's Institute of Engineering (Nepal) tested the low cost set with farmers at another site at Kubinde village, Kavre.

PARDYP started research on drip irrigation at an agricultural research station (the Spices Crop Development Centre at Tamaghat, Kabhrepalanchok) and brought different stakeholders, principally farmers, to the station to learn. After seeing the trials some farmers, especially those living near the research station, started testing drip irrigation on their farms. From 2001 to 2004, PARDYP subsidised 50% of the cost of the drip sets to most adopting farmers.

PARDYP organised several farm visits for stakeholders to the research station and farmers' fields. The number of interested farmers increased and many started testing and demonstrating the technology on their farms. PARDYP provided technical support during installation, advice about water application, and trouble shooting training to user farmers. Soon, many farmers started using drip irrigation with little or no technical support from PARDYP. Some collected quantitative and qualitative information on the performance of their systems. Results and experiences were shared regularly after cropping seasons through interaction meetings. Users' experiences convinced many others to adopt the technology.

Interaction meetings were organised to communicate farmers' feedback to the organisation and businesses involved in making the drip sets. Farmers from the watershed were taken to the drip set manufacturers to establish a direct link between them and to allow the project to phase out its support.

This approach emphasised on-station to on-farm research and demonstration to facilitate ongoing monitoring and evaluation of the performance of locally made drip sets.

WOCAT database reference: QA NEP6
Location: Jhikhu Khola watershed, Kabhrepalanchok district, Nepal
Approach area: 111 km^2
Land use: Annual cropping
Climate: Humid subtropical
Related technology: Low cost drip irrigation, QT NEP6
Compiled by: Madhav Dhakal, ICIMOD
Date: August 2006, updated September 2006

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

Problem, objectives and constraints

Problem

- Lack of systematic on-farm research on drip irrigation
- Weak institutional collaboration for developing, disseminating and scaling up drip technology
- Inadequate water available for agriculture alongside strong seasonality and poor irrigation facilities

Objectives

- To test, demonstrate, and evaluate drip irrigation systems under local conditions with multiple stakeholders
- To share results and experiences with communities to scale up the technology

Constraints addressed

Major	Specification	Treatment
Technical	Promotion of micro irrigation was not a priority of line agencies in the study area	Technology implemented with multiple stakeholders' participation
Financial	Insufficient government incentives	A cost-effective technology and implementing approach
Institutional	Weak institutional collaboration among line agencies	Participatory action research with several institutions – universities, local research centres, and farmers
Minor	**Specification**	**Treatment**
Other	Lack of awareness on potential water-saving options	Community-based training, discussions and field visits

Participation and decision making

Target groups


Land users


Extension workers

Approach costs met by:

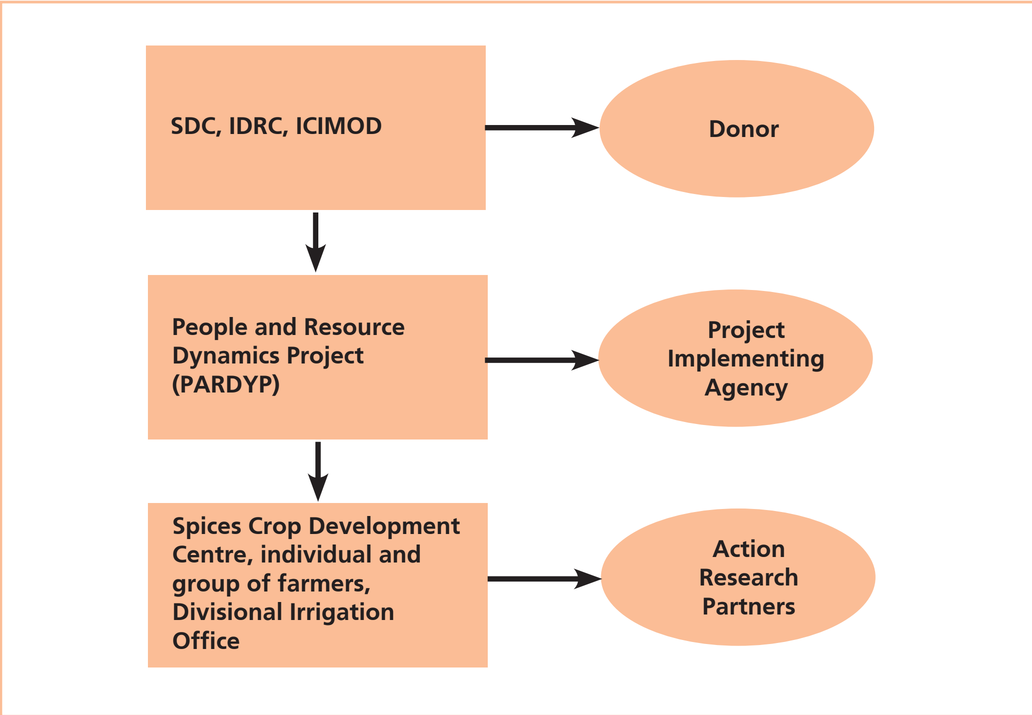
International donor-funded project (PARDYP)	50%
Community/local	50%
TOTAL	**100%**

Decisions on choice of the technology: Mainly national soil and water conservation (SWC) specialist in consultation with land users. The project tested drip irrigation as a promising water-efficient technology.
Decisions on method of implementing the technology: Mainly SWC specialist in consultation with land users. It was tested first in the research station to build confidence of the project staff and surrounding villagers, and was then taken to interested farmers' fields.
Approach designed by: National specialist and land users. The approach was implemented jointly by national specialists and land users.

Community involvement

Phase	Involvement	Activities
Initiation	Interactive	A water demand and supply survey identified problem of lack of water in the dry season for irrigating crops. The concept of drip irrigation was shared at public meetings and a demonstration plot established at a local agricultural research centre. Several farmer visits organised to the research centre.
Planning	Interactive	At the public meetings, farmers showed interest in drip irrigation. The project supported them by transporting drip sets to the nearest roadhead and subsidising the purchase costs.
Implementation	self-mobilisation	Farmers implemented the technology and the project provided technical support.
Monitoring/ evaluation	Interactive	Farmers monitored the technology with project support. Evaluation was usually done at meetings and exchange visits.
Research	self-mobilisation	The technology was tested at the local research centre during the first few years followed by on-farm research with farmers. Farmers collected and analysed quantitative and qualitative information themselves.

Differences in participation of men and women: Only 20% of total participants were women



PARDYP project donors and implementing partners
SDC: Swiss Agency for Development and Co-operation
IDRC: International Development Research Centre
ICIMOD: International Centre for Integrated Mountain Development

Extension and promotion

Training: Training programmes were organised on how to install and maintain the drip systems. Likewise farmers were trained on record keeping for water application, production, and cost-benefit analysis. The different target groups became more knowledgeable about the technical aspects of drip irrigation, and the economic benefits of using drip irrigation to grow vegetable crops.
Extension: Farmer-to-farmer dissemination and the traditional extension approach took place at interactive meetings, on-station and on-farm demonstration visits, and workshops. The projects' own extension structure and other agents facilitated this work with support from the government's existing extension system within the Spices Crop Development Centre. The various target groups became more aware about water conservation and efficient irrigation methods. The number of farmers adopting the technology significantly increased as a result of this approach.
Research: Action research was carried out to compare the water requirements, the cost-benefit, and the advantages and disadvantages of traditional and drip irrigation. The project's focus on research helped to improve knowledge on water saving and cost-benefit analysis.
Importance of land use rights: Individual land ownership helped to implement this approach and to disseminate and scale up the technology as there were no conflicts among land users.

Incentives

Labour: None
Inputs: 50% subsidy on drip kits provided by the project during initial stages to a few farmers.
Support of local institutions: On-site training during drip installation provided to a local NGO (Ranipani Gram Sewa Kendra) with vegetable seedling support.
Long-term impact of incentives: The incentives at the beginning helped raise awareness amongst land users and to spread the technology. In the long-term farmers who received incentives are getting good economic benefit from the technology.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Biophysical	ad hoc observations on land use change, crop rotation, soil surveys
Technical	regular measurements of water requirements
Socio-cultural	ad hoc observations through socioeconomic surveys
Economic/production	regular measurements of cost-benefit and production
Area treated	regular measurements of area under drip irrigation
No. of land users involved	regular recording of number of drip users

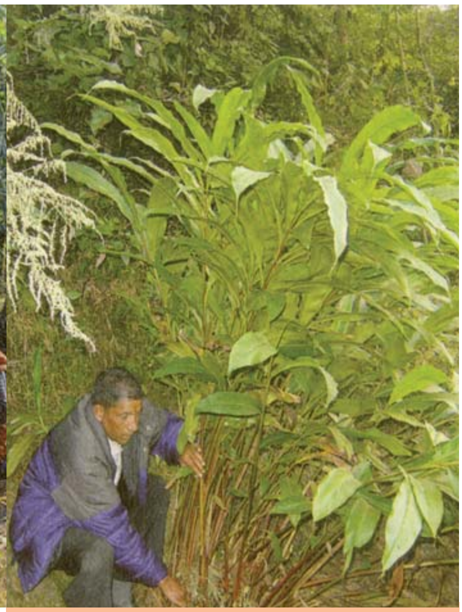
Impacts of the approach

Changes as a result of monitoring and evaluation: Few changes were made: the subsidy system was withdrawn and work with groups rather than single households was started. In addition, interaction programmes were organised at different locations in the watershed.
Improved soil and water management: Land users started cropping land that was previously left fallow in the dry season and increased the area under cash crops – especially vegetables. Drip irrigation used only 60% of water compared to bucket irrigation.
Adoption of the approach by other projects/land users: A few institutions and district level line agencies like Ranipani Gram Sewa Kendra, a local NGO, and the Divisional Irrigation Office Kabhrepalanchok started organising interactive meetings to discuss drip irrigation.
Sustainability: Most of the land users continue to use drip irrigation and are maintaining the sets. A few farmers, including women, abandoned drip after using it for some time. The women who abandoned it said they did so because of "lack of technical knowledge", "not enough labour" and "too far to get water"

Concluding statements

Strengths and ➔how to sustain/improve	Weaknesses and ➔how to overcome
This approach emphasises the participation of multiple stakeholders in researching, disseminating, and scaling up the use of the technology ➔ Identify and involve new interested stakeholders	Many local land users remain unaware about the potential of drip irrigation technology ➔ Make more funds available to further promote the technology
On-station and on-farm research was important to get results from different locations and under different conditions ➔ Continue research to acquire in-depth knowledge on performance of drip irrigation under different conditions	Women drip farmers' constraints were not sufficiently addressed ➔ Women's priorities and constraints must be better understood and addressed by programmes and projects on drip irrigation
Regular interaction meetings provided land users with a platform to share ideas and for non-adopters to learn about drip from users ➔ Continue such meetings and involve more potential adopters	
Farmer-to-farmer visits were helpful to build confidence of farmers by seeing on-site results ➔ As above	
On-site training on drip installation and maintenance helped build confidence in using drip sets ➔ As above	

Key reference(s): ICIMOD (2007) *Good Practices in Watershed Management, Lessons Learned in the Mid Hills of Nepal.* Kathmandu: ICIMOD; Shrestha-Malla, S. (2004). Adoption of Drip Technology and its Impact on Gender: a Case Study from Jhikhu Khola Watershed, Nepal. PARDYP/ICIMOD (unpublished)
Contact person(s): HIMCAT/WOCAT Coordinator, International Centre for Integrated Mountain Development (ICIMOD), GPO Box. 3226, Kathmandu, Nepal, himcat@icimod.org



Left: On-site training for members of Salambudevi Community Forest User Group, Sankhu, Salambutar, organised by the Department of Soil Conservation and Watershed Management. (BIWMP)
Right: A farmer with a mature cardamom plant – one of the vegetative measures which add a productive component to the landslip and stream bank rehabilitation technology (Hanspeter Liniger)

Integrated watershed management for landslip and stream bank stabilisation

Nepal: पहिरो र नदीकिनार कटान रोकथामका लागि एकीकृत जलाधार व्यवस्थापन

Integrated watershed management as an example for landslip and stream bank stabilisation based on fostering a partnership between community institutions, line agencies, district authorities and consultants

The sustainable management of mountain watersheds is a huge challenge for watershed management programmes due to the lack of collaboration between the various institutions involved. Building of synergies between these institutions is crucial for improved management. The Bagmati Integrated Watershed Management Programme (BIWMP) started in 1986, initiated, coordinated, and organised by the Department of Soil Conservation and Watershed Management with support from the European Commission. The programme aimed to help overcome natural resource degradation and thereby raise the standard of living of the rural population.

The main causes of degradation and options to address the related problems were identified through participatory action research. Landslip and stream bank stabilisation was identified as one of the most promising and needed options to conserve soil and water, whilst providing direct livelihood benefits to local people, for example planting of large cardamom, later used as a cash crop, and reestablishment of damaged agricultural terrace above the landslip. The approach was to foster partnership between and among communities, district authorities, line agencies, and consultants. Key priorities were to ensure the equitable involvement of women and socially disadvantaged people and to promote local ownership, institutional capacity building, and sustainability. The programme used participatory extension methods such as farmer-to-farmer exchange, training workshops, and on-site demonstrations, with participatory approaches to planning, implementing, and monitoring. The activities were based on villager's priorities and were implemented by individual households, farmer groups, and village institutions. The local village development committee, local NGOs, community forest user group, and individual households worked together on landslip and stream bank stabilisation. Involving a range of stakeholders was paramount for success.

The first phase began in 1986 and focused on developing technical packages which were implemented through user groups. The second phase focused on improvements to implementation procedures, especially community organisation, extension, and income generation activities. The capacity of community groups was developed by establishing communication facilities, building up community networks, and empowering women and disadvantaged groups. BIWMP ended in 2003 with much of its success attributed to the close involvement of all the main stakeholders, and especially the local people, in all the activities. It successfully helped land users to adopt improved livelihood options.

WOCAT database reference: QA NEP11
Location: Lalitpur, Kathmandu, Makwanpur, Bhaktapur, and Sindhuli districts; Bagmati river basin, Nepal
Approach area: 570 km^2
Land use: Wasteland (before), mixed agrosilvopastoral (after)
Climate: Humid subtropical
Related technology: Landslip and stream bank stabilisation, QT NEP11
Compiled by: Dileep Kumar Karna, Department of Soil Conservation and Watershed Management, District Soil Conservation Office, Kathmandu, Nepal
Date: December 2003, updated August 2004

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

Problem, objectives and constraints

Problem
- Lack of institutional capacity and collaboration for managing watershed resources

Objectives
- To overcome the constraints to effectively implementing a watershed management programme by building synergies between diverse stakeholder institutions. In the case of landslip and stream bank stabilisation work, the specific objective was to come up with a technology that conserved soil and water whilst also providing direct livelihood benefits to local people.

Constraints addressed

Major	Specification	Treatment
Institutional	Lack of inter-institutional collaboration	Building and ensuring collaboration
Technical	Lack of new options	Training on new technologies
Minor	**Specification**	**Treatment**
Social/cultural/ religious	Following conventional top-down approaches	Introduction of improved methods with more participation and involvement of land users

Participation and decision making

Target groups

Land users | SWC specialists/ extensionists | Planners | Politicians/ decision makers | Teachers and students

Approach costs met by:

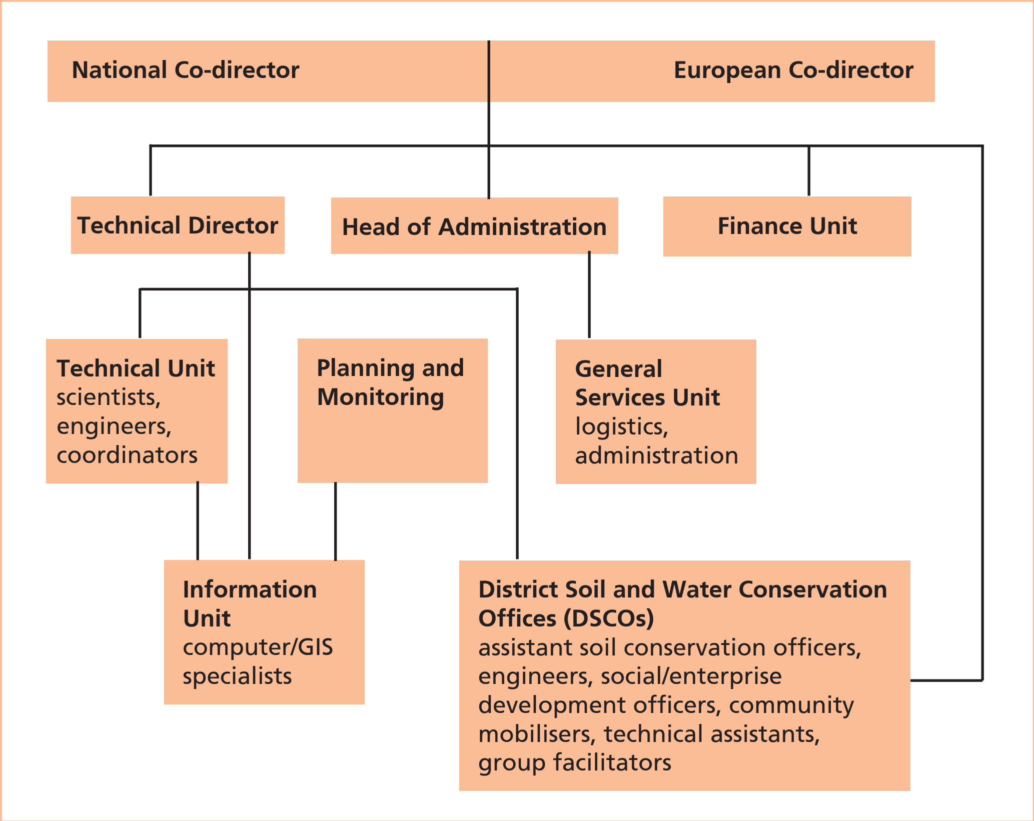
International agency: the European Commission	81%
Community/local people	15%
National government	4%
TOTAL	**100%**

Decisions on choice of the technology: Mainly made by soil and water conservation (SWC) specialists in consultation with land users as the land users did not know about the technologies
Decisions on method of implementing the technology: Mainly made by SWC specialists in consultation with land users as measures required technical know-how
Approach designed by: Mainly by international and national specialists, and partly by land users. For the landslip and stream bank stabilisation technology, the approach was mainly designed by programme staff of the Kathmandu District Soil Conservation Office

Community involvement

Phase	Involvement	Activities
Initiation	Interactive	Rapid/participatory rural appraisal
Planning	Interactive	Rapid/participatory rural appraisal
Implementation	Interactive	Responsible for major steps
Monitoring/ evaluation	Interactive	Reporting, measurements/observations, public meetings, workshop/ seminars
Research	Interactive	On-farm trials

Differences in participation of men and women: BIWMP took a bottom-up approach to planning and implementation and encouraged the equitable involvement of women in its activities. The decisions about implementing the landslip and stream bank stabilisation technology were taken jointly by men and women. However, contributions to establishing and maintaining the technology were made according to the traditional pattern of work allocation with, for example, digging mainly done by men and planting and watering mainly done by women.



Organogram
Organogram of the Bagmati Integrated Watershed Management Programme (BIWMP). The landslip and stream bank stabilisation work was implemented by the Kathmandu District Soil Conservation Office supervised by an assistant soil conservation officer (engineer).

Extension and promotion

Training: Training was provided to local people on soil and water conservation by arranging visits to demonstration sites and farms and at public meetings. This had a very positive impact on land users and SWC specialists, enabling them to easily implement horticultural, bioengineering, and agroforestry practices. The effectiveness of the training on extension agents, planners, and politicians was good, but only fair for teachers and students who are only using the programme's educational materials to a limited extent.

Extension: The extension approach taken was integrated watershed management using participatory rural appraisal, training, farmer-to-farmer exchange, workshops, seminars, and on-site demonstration. The impact on land users was excellent. Extension focused on land users and SWC specialists acting together, and provided opportunities for them to test various technologies for watershed management. The involvement of village politicians, project decision-makers, and planners in monitoring the impact of the extension work helped to develop watershed management activities for use in other areas.

Research: Research was an important part of the approach. All research components (sociology, economics/marketing, ecology, and technology) were covered (see key references below) by consultants and staff members. The participatory action research activities made a large contribution to the approach’s effectiveness while involving many stakeholders.

Importance of land use rights: The fact that the land was communal land (state property, use right with community) greatly helped smooth implementation of the approach as it was not necessary to deal with different land users.

Incentives

Labour: About 75% of the labour for the landslip and stream bank stabilisation work was voluntar. The remainder was paid for in cash.

Inputs: Cement, bricks, and stones for community infrastructure were fully financed by the programme, whereas seeds, seedlings, and saplings were either not or only partly financed.

Credit: No credit was provided.

Support of local institutions: The programme provided considerable support to local institutions in the form of training and equipment.

Long-term impact of incentives: While clear positive environmental effects resulted from providing incentives such as cement, bricks, and stone, which led to improved management of the watershed and improved livelihood security, there is a risk that local communities could become too dependent on external funds for future work.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Biophysical	ad hoc measurement of land use change
Technical	regular observations
Socio-cultural	regular observations of status
Economic/production	regular observations of cash income
Area treated	ad hoc measurements: GIS mapping
No. of land users involved	irregular observations of numbers
Management of approach	regular monitoring reports

Impacts of the approach

Changes as a result of monitoring and evaluation: The approach described was designed on the basis of the results shown through monitoring and evaluating the first phase of BIWMP (1986-1992). In the second phase from 1992, more attention was focused on building up the capacity of community groups to plan, implement, and continue development activities. Capacity was built through (1) community-level training; (2) supporting the installation of communication facilities (telephone, radio, etc.); (3) developing a strategy for empowering women and disadvantaged groups; and (4) assisting the establishment of community networks.
Improved soil and water management: The approach helped to improve soil and water management by promoting many activities related to agroforestry, water harvesting, landslip stabilisation, and community forestry. Many local land users adopted these technologies.
Adoption of the approach by other projects/land users: It is not known whether this approach has been taken to address landslip and stream bank erosion problems in other areas by other projects.
Sustainability: The land users were keen on maintaining the implemented technologies due to the benefits they could get from it. There has to be a strong driving force within the land users and the community to continue this approach.

Concluding statements

Strengths and ➔how to sustain/improve	Weaknesses and ➔how to overcome
Involves all key actors in watershed management ➔ Institutionalise the approach	The approach is 'project focussed' ➔ Institutionalise the approach
Helped land users improve their livelihoods ➔ Similar approaches should be implemented by government and community programmes	The approach does not focus on landless families ➔ Implement watershed management activities that involve and benefit landless people
The approach encourages land users communities and local institutions to get involved in planning and decision making ➔ Involve them more in planning and decision making	Some activities with high input requirements may not be spontaneously adopted by poor land users ➔ Further research on how to reduce inputs or provide specific incentives for such disadvantaged groups
The implementation of technologies through this approach is cost-effective and socio-culturally acceptable ➔ Take into account local resources and knowledge	

Key reference(s): BIWM (1998 to 2001) *Annual Workplans for Project Years 1998 to 2002,* prepared for Government of Nepal, Ministry of Forest and Soil Conservation, Department of Soil Conservation and Watershed Management and the Commission of European Communities. Kathmandu, Nepal ■ Mallik, D.B. (2000) 'Working with Community'. In Jaladhar-Quarterly Newsletter of Bagmati Integrated Watershed Management Programme, Issue 2
Contact person(s): HIMCAT/WOCAT Coordinator, International Centre for Integrated Mountain Development (ICIMOD), GPO Box. 3226, Kathmandu, Nepal, himcat@icimod.org

Left: Land users preparing eyebrow pits with women actively involved (PARDYP)
Right: Land users sowing seeds of grass and hedgerow species (PARDYP)

Local initiatives for rehabilitating degraded communal grazing land

Nepal: क्षतिग्रस्त सामुदायिक चरण भूमि पुनर्उत्थानमा स्थानीय अग्रसरता

Supporting local initiatives and building local capacity for the rehabilitation of degraded communal land in the middle mountains of Nepal

The main aim of the People and Resource Dynamics Project's (PARDYP) land rehabilitation activities were to help watershed residents, local groups, and line agencies understand the key issues and to test options for the improved management of water, land, and forests in a participatory way. In Dhotra VDC (Kabhrepalanchok district) a local youth club (Ekantabasti Youth Club) had been trying to rehabilitate a 2.5 ha area of degraded communal land since May 2004. The club approached PARDYP for technical assistance. The area had been degraded by overgrazing with two big gullies formed and small landslips along the gullies affecting a trail and the adjoining agricultural land.

An unsuccessful attempt had been made to plant the area eight years previously. It had failed due to the difficulty of retaining soil moisture in the area's compacted red soils. A series of meetings were organised to plan future activities, to ensure community participation, and to share responsibilities among local users and PARDYP. The community was committed to rehabilitating the area and took the responsibility for planting, protection, and overall management of the planted species. PARDYP provided planting materials and technical help.

A needs assessment with the local people identified the most useful tree species. They entrusted the selection of appropriate grass and hedgerow species to the project's expertise. Project staff arrange for planting materials and logistical support, and showed villagers how to make eyebrow pits, plant hedgerows, and plug gullies. About 450 villagers participated in the rehabilitation activities with women contributing more than half of the labour. They worked four hours a day for 16 mornings.

A five-women strong user committee was formed to manage and protect the planted species and a five-man strong task force was set up to maintain regular links and coordination between the user committee, the youth club, and the villagers. The coordination committee, with guidance from the youth club, was responsible for facilitating and coordinating all the second season rehabilitation work in 2005.

WOCAT database reference: QA NEP13
Location: Dhotra village, Jhikhu Khola watershed, Kabhrepalanchok district, Nepal
Approach area: 0.025 km^2
Land use: Extensive grazing
Climate: Humid subtropical
Related technology: Rehabilitation of degraded communal grazing land and gully plugging, QT NEP13 and QT NEP14
Compiled by: Madhav Dhakal, ICIMOD
Date: October 2006

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

Problem, objectives and constraints

Problem
- Lack of awareness about low cost soil and water conservation technologies that address farmers' needs
- Weak institutional collaboration for developing and implementing technologies

Objectives
- To demonstrate appropriate technologies for rehabilitating degraded land and evaluating their effectiveness
- To provide training on soil and water conservation (SWC) technologies for effectively implementing the rehabilitation activities and to build the capacity of the local community to carry out the work
- To organise and mobilise a local community for implementing, protecting and managing the planted areas and the physical structures

Constraints addressed

Major	Specification	Treatment
Technical	Limited knowledge of appropriate SWC technologies and limited technical know-how to implement them	On-site training and exchange visits organised to demonstration sites
Institutional	Weak institutional collaboration for technology development and demonstration	Collaboration with local youth club; formation of user committee and task force
Minor	**Specification**	**Treatment**
Financial	Government incentives lacking	Cost-effective technology demonstrated; planting materials and other logistic support provided

Participation and decision making

Target groups


Land users


Extension workers

Approach costs met by:

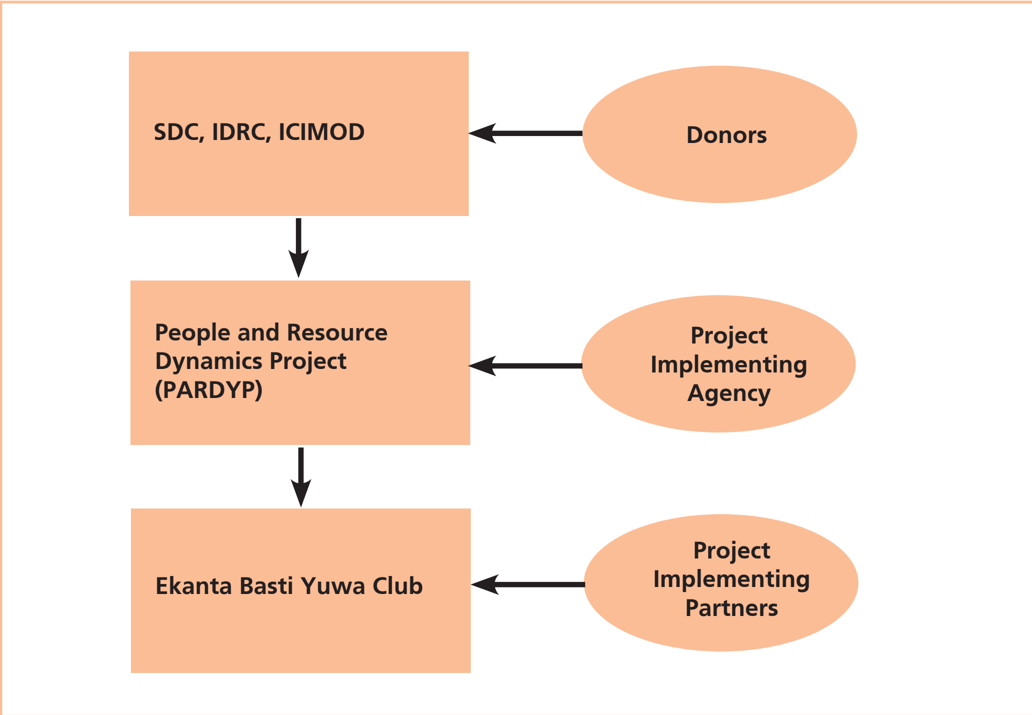
International donor funded project (PARDP)	90%
Community/local	10%
TOTAL	**100%**

Decisions on choice of the technology: Mainly national SWC specialist (PARDYP experts) in consultation with land users and local youth club
Decisions on method of implementing the technology: Mainly land users supported by national SWC specialists. Villagers took the responsibility for planting, protecting, and overall management of the planted species. PARDYP arranged planting materials and technical support
Approach designed by: National specialist together with local youth club. Initiation and implementation by local youth club representing land users. Technical and logistics support by national specialists

Community involvement

Phase	Involvement	Activities
Initiation	Interactive	Local youth club approached PARDYP for technical help during a meeting
Planning	Interactive	Public meetings organised to share responsibilities. Land users took responsibility for land preparation, planting, protection, grazing control, and overall management of planted species. Men and women performed planned activities together. Construction of eyebrow pits done mostly by men. Filling of cement bags with soil for check dams mostly done by women while check dams were built by men. PARDYP provided planting materials and technical help. PRA tool used for selecting tree species
Implementation	Self-mobilisation	Self-mobilised group under leadership of youth club implemented the activities; technical guidance during implementing period provided by project
Monitoring/ evaluation	Interactive	Survival of planted species, effect of eyebrow pits, performance of species and check dams were monitored/observed. Results shared in public meetings and reported to the project

Differences in participation of men and women: Women's participation was a little higher, they provided 56% of the labour.



PARDP project donors and implementing partners
SDC: Swiss Agency for Development and Cooperation
IDRC: International Development Research Centre
ICIMOD: International Centre for Integrated Mountain Development

Extension and promotion

Training: On-site training sessions were organised for establishing the eyebrow pits, contour hedgerows, gully treatments, and check dams and their maintenance. The trainings have made land users capable of implementing the rehabilitation activities in other areas and maintaining the current site.
Extension: The key elements of the extension approach were on-site training, demonstration, exchange visits, and public meetings. After implementing the technology, a number of exchange and interaction, audio visual presentation, and monitoring programmes were carried out as a scaling up strategy. The involvement of multiple stakeholders in the programmes helped in evaluating the technology. This led to the land users planning to scale up the SWC activities in their community forest themselves and technicians being able to implement the technologies and approach in other areas. However, planners and decision makers had only limited involvement in the initiative.
Research: Research was not a major focus of the approach although the performance and survival rates of planted species, and performance of eyebrow pits and connecting drainage trenches were regularly observed.
Importance of land use rights: The land is owned by the state and prior to starting the work there was a conflict over where the boundaries lay. Adjacent private landowners illegally claimed a part of the land but withdrew their claims before the rehabilitation work started. The existing land ownership and land use rights hindered the implementation of the approach at the beginning.

Incentives

Labour: Land users involvement was fully voluntary; they worked together in a cooperative spirit to improve their common degraded land.
Inputs: The project provided grass seeds and seedlings free of charge from its seed bank. Trees were provided by the Department of Forests, and some trees were locally sourced.
Credit: No credit was provided.
Support of local institutions: Moderate, some technical training was provided to local youth club.
Long-term impact of incentives: The main incentive provided was training that has enabled the community to improve the degraded land under its own efforts by reducing soil loss and establishing a green cover over the area.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Biophysical	ad hoc observations on soil type and texture
Technical	regular observations of performance of planted species and their survival rates
Socio-cultural	ad hoc observations on farmers' preferred tree species and on closing the area for grazing
Economic/production	ad hoc observations on seed and grass production
No. of land users involved	ad hoc observation of land users' participation in maintaining planted species and structures

Impacts of the approach

Changes as a result of monitoring and evaluation: The users increased the size of the eyebrow pits and dug new pits and extended the hedgerow lines to fill in gaps; but the overall approach was not changed
Improved soil and water management: An organised land users' group was formed and awareness of SWC increased
Adoption of the approach by other projects/land users: The approach adopted during rehabilitation activities is quite standard and is taken by many other land management and community development projects
Sustainability: Land users planned to upscale the technology and its related approach to rehabilitate the degraded areas of their community forest but it hasn't happened yet.

Concluding statements

Strengths and ➔how to sustain/improve	Weaknesses and ➔how to overcome
This is a bottom-up approach with the rehabilitation activities purely demand driven. Farmers' priorities for tree species to be planted were identified in a participatory way ➔ Continue by including new priorities	Collaboration with government line agencies was lacking ➔ Rehabilitation work should be carried out involving all main stakeholders
The local youth club played a key role in rehabilitation activities – a key factor for sustainability and continuity ➔ More local institutions should be identified and involved.	Research was not a main focus of the activity, and not enough options were explored➔ Explore and test more options
Among total participants, women's participation was higher. User committee was made up of just women ➔ Continue this	
Site visits and focus group discussion meetings were effective for disseminating and scaling up the approach➔ Continue these initiatives on a regular basis to strengthen land users' involvement in SWC activities	
Suitable technologies were shared and valuable knowledge given during the rehabilitation work ➔ Continue this incorporating new ideas	
Community institution strengthened, and some money (US$ 17) raised by selling grasses and grass seed within two years of rehabilitation. Money used for social activities➔ As above	

Key reference(s): ICIMOD (2007) *Good Practices in Watershed Management, Lessons Learned in the Mid Hills of Nepal.* Kathmandu: ICIMOD
Contact person(s): HIMCAT/WOCAT Coordinator, International Centre for Integrated Mountain Development (ICIMOD), GPO Box. 3226, Kathmandu, Nepal, himcat@icimod.org

Left: Farmers and technicians observing an SRI field as part of a farmer field school (Madhav Dhakal)
Right: A farmer sharing her field experiences at a farmer field school (Madhav Dhakal)

Evaluation of the System of Rice Intensification (SRI) through participatory research and development

Nepal: सहभागीतामूलक अनुसन्धान र विकासद्वारा धान उत्पादन वृद्धि गर्ने तरीकाको मूल्यांकन

Conducting participatory action research with farmers and district level line agencies for demonstrating, disseminating and scaling up SRI

PARDYP pilot tested SRI in the Spice Crop Development Centre (SCDC) at Tamaghat, Kabhrepalanchok in 2002. The positive results led the technique to be tried out in 25 farmer's fields in 2004 to evaluate whether SRI was technically feasible in the Himalayan middle mountains. Based on farmers' interests and to promote SRI systematically, PARDYP organised interaction programmes between farmers who had and had not used SRI, village level group discussions, farmer-to-farmer visits and farmer-led on-site monitoring and evaluation in 2002, 2003 and 2004.

In 2005, the emphasis shifted to carrying out research with groups of farmers in a more systematic way and participatory rural appraisal methods and tools were used. The approach was called the SRI farmer field school (FFS) approach. Lead farmers (13 male and 6 female) were trained as SRI trainers and then facilitated village level farmer field schools for testing and promoting SRI. In 2005, SRI farmer field schools were run in 15 villages for about 100 farmers. Each school carried out hands-on training sessions to help farmers understand (1) the basic concepts of SRI and its practices, (2) methods for comparing traditional practices with SRI, and (3) how to observe, analyse and present findings more systematically. Monitoring and evaluation gathered both men's and women's perceptions. This also helped establish an informal farmer-learning network in the watershed. Village level discussions, farmer visits, and interaction with staff from the district agriculture offices continued. At the end of the on-farm experiments, a district level farmer's day was organised to share the experiences gained.

To promote wider understanding of the action research and encourage farmers to continue developing and adapting SRI, the project disseminated information about SRI through information, education and communication (IEC) materials aimed at community-level users, and a multi-media package on a CD ROM for the global audience and Nepali policy-makers and administrators. A national exchange workshop was held to share experiences from across the country on the use of SRI.

WOCAT database reference: QA NEP15
Location: Jhikhu Khola watershed, Kabhrepalanchok district, Nepal
Approach area: 111 km^2
Land use: Annual cropping
Climate: Humid subtropical
Related technology: System of rice intensification (SRI), QT NEP15
Compiled by: Madhav Dhakal, ICIMOD
Date: August 2006

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

Problem, objectives and constraints

Problem

- Lack of systematic on-farm research for developing a technology that takes into account farmers' needs
- Weak institutional collaboration for technology development, dissemination and scaling up
- Poor soil fertility, limited crop production, and poor irrigation facilities

Objectives

- To demonstrate and evaluate the innovative SRI technique under local conditions with land users' participation
- To inform farmers about the basic concepts, associated principles, and technical know-how related to SRI
- To share knowledge gained on SRI with a wider audience
- To scale up the innovation across larger areas

Constraints addressed

Major	Specification	Treatment
Technical	It is not a priority area of line agencies	Sharing of technical know-how with concerned stakeholders
Institutional	Lack of coordination among land users	Informal SRI farmers' network established with trained human resources
Minor	**Specification**	**Treatment**
Financial	Government incentives lacking	The innovation is cost effective and doesn't need additional inputs
Other	Lack of awareness	Trainings, group discussions, field visits

Participation and decision making

Target groups


Land users


Extension workers


Planners

Approach costs met by:

International donor funded project (PARDP)	90%
Community/local	10%
TOTAL	**100%**

Decisions on choice of the technology: Mainly national soil and water conservation (SWC) specialists in consultation with land users, including women farmers
Decisions on method of implementing the technology: Mainly SWC specialists in consultation with land users. It was tested first at a research station to build confidence of project staff and surrounding villagers, and was then taken to interested farmers' fields
Approach designed by: National specialist together with land users

Community involvement

Phase	Involvement	Activities
Initiation	Passive	First year's on-station demonstration with results shared at public meetings
Planning	Interactive	Public meetings organised in different villages; villagers selected lead farmers for the training, and orientation meeting held to plan activities
Implementation	Interactive	Farmers themselves implemented the activities; the project facilitated the research and arranged logistics
Monitoring/ evaluation	Interactive	Measurements, observations and reporting were carried out once a week. At the end of the project, results were evaluated through interviews using questionnaires. Public meeting organised to share results with district level stakeholders
Research	Interactive	On-farm and on-station research conducted; information from research station collected by technicians; farmers themselves collected information from their fields

Differences in participation of men and women: There was 30% women's participation

Left: Public meeting: an orientation meeting to plan and implement SRI activities (Madhav Dhakal)
Right: Lead farmers in the demonstration field – an activity of a farmer field school (Madhav Dhakal)

Extension and promotion

Training: The training courses covered the principles associated with SRI, participatory research procedures, and farmers' concerns (men and women). On-station and on-farm plots were established to compare the results from SRI and traditionally grown rice. Farm visits were run regularly for ordinary SRI farmers to interact with lead farmers. Public meetings were organised to share SRI principles and experiences with non-participating farmers. Most of the trainings were effective.
Extension: The approach focused on the farmer-to-farmer extension of SRI by involving local farmers as facilitators. The trained farmers facilitated and shared their experiences with new SRI farmers. Local meetings (farmers days) and national workshops were run to scale up the SRI method and share lessons learned. These events were very important to raise awareness and to promote SRI, with different stakeholders taking part and sharing their views. The extension was quite successful and a large number of farmers are now able to confidently implement SRI. However, the awareness of decision makers and politicians needs to be improved.
Research: Participatory research at the farmer field schools was a key element of the approach. The schools compared the inputs and outputs of the traditional and SRI methods including the differences in grain and biomass production, the costs and benefits, and the advantages and disadvantages. Research helped participating farmers understand better the principles and practices of SRI in a real field situation.
Importance of land use rights: The individual land use rights helped in implementing the technology as there were no conflicts among land users.

Incentives

Labour: Labour was voluntary with farmers working either as trainees or volunteers.
Inputs: The project provided seed, fertiliser and biocide for on-station and on-farm demonstration plots; nothing was provided to the individual SRI farmer's fields.
Credit: No credit was provided.
Support of local institutions: None
Long-term impact of incentives: The necessary incentives (especially training) for implementing SRI in the long term helped enormously in wider SRI adoption.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Biophysical	ad hoc observations on soil condition and irrigation facilities
Technical	regular measurement (weekly) of number of tillers, tiller height, climatic conditions
Socio-cultural	ad hoc observations on farmers' (male and female) preference for rice varieties
Economic/production	regular measurement of grain and biomass production, cost of production
Area treated	ad hoc measurement of area of SRI cultivation
No. of land users involved	ad hoc observation of frequency of farm visits and record keeping
Management of approach	regular observation of the training management by farmer field school management sub-committees

Impacts of the approach

Changes as a result of monitoring and evaluation: The recommendations of external evaluation led to research designs being adjusted to better address farmers' needs, for example: 1) plant spacings of 25cm x 25cm and 50cm x 50cm tested under rainfed conditions and with irrigation over dry spells; 2) 10-15 day old seedlings transplanted; 3) different varieties of monsoon rice tested; 4) full dose (NPK 100:30:30) chemical fertiliser and half dose (NPK 50:15:15) chemical fertiliser with half dose compost tested; and 5) rice intercropped with soybean.
Improved soil and water management: The approach has helped participating farmers to improve soil and water management. They started to apply the recommended dose of chemical fertiliser and improved farmyard manure. The frequency of irrigation was reduced and there were less cases of terrace-riser failure caused by stagnant water. The SRI method consumed 50 to 75% less water, 75% less seeds, 50% less labour for transplanting, 50-60% less labour for irrigation and less costly pesticides than the traditional method.
Adoption of the approach by other projects/land users: A similar approach was used to promote SRI by a few projects in the same district.
Sustainability: The approach can be continued without external support. By 2005, about 35 local land users had adopted the SRI method and previous adopters were continuing to use SRI. However, some more time may be required for its wider adoption.

Concluding statements

Strengths and ➔how to sustain/improve	Weaknesses and ➔how to overcome
Action research was conducted with farmer groups and individual households. The group approach was more systematic and helped to build confidence of land users in the technology ➔ It should be maintained and continued on a regular basis to strengthen land users' involvement	Due to time limits, not all SRI adopters' opinions and experiences could be covered during interaction workshops. The scattered farmer field schools (distance-wise) and the difficult political situation meant that exchange visits could not be organised for all schools ➔ Allocate enough time for such programmes
Action research was conducted through farmer field schools and lead farmers were trained in training of trainers programmes. These served as platforms for farmers to share their immediate concerns. Besides analysing and presenting, farmers' skills were also developed ➔ Implement the farmers field school approach during technology implementation to build confidence of land users and empower them in soil and water conservation	Women's participation in the village level workshops was poor (2% at one location and 5% at another) ➔ Encourage women to participate, and adapt programmes to suit their interests
Lead farmers served as key resource persons in the village-level farmer field schools. Data from test plots were analyzed by farmers on a weekly basis. This was very effective for promoting the sustainability of SRI ➔ Encourage district level agriculture offices to use the skills of lead farmers as resource persons to expand SRI in their districts	Agro-ecosystem analysis, as used at the farmer field schools, became a time-consuming process as participants had to spend much time in preparing presentations ➔ Pre-planning and pre-preparation of presentation format should reduce the time length
Participatory methods and tools were applied repeatedly. Farmer visits and village level group discussions were very effective for evaluating SRI ➔ Use participatory tools and methods widely during the technology implementing period	A long dry spell meant that the SRI observation plot could not be established near to the lead farmers' field school site, and only 15 facilitators were able to establish observation plots in their villages ➔ This was due to natural causes (late arrival of monsoon), it can be improved easily if monsoon arrives on time
Through farmer-to-farmer field visits, farmers had an opportunity to observe others' fields and see the performance of SRI in different locations and conditions ➔ Continue such visits as farmers learn much more from farm visits and from sharing experiences with other farmers	

Key reference(s): ICIMOD (2007) *Good Practices in Watershed Management, Lessons Learned in the Mid Hills of Nepal.* Kathmandu: ICIMOD ■ Dhakal, M.P. (2005) *Farmers' Evaluation of System of Rice Intensification in Middle Mountains of Nepal.* Cornell International Institute for Food, Agriculture, and Development (CIIFAD) SRI.URL: http://ciifad.cornell.edu/sri/countries/nepal/index.html ■ IRRI International Rice Research Institute, www.irri.org.
Contact person(s): HIMCAT/WOCAT Coordinator, International Centre for Integrated Mountain Development (ICIMOD), GPO Box. 3226, Kathmandu, Nepal, himcat@icimod.org

Left: A meeting between project technicians and users to discuss problems and issues related to drinking water and to identify viable solutions. (PARDYP)
Right: Sharing simple water quality treatment methods like SODIS and the low cost Safa filter with users. (B.S. Dongol)

Community efforts for improving drinking water quality

Nepal: **पिउने पानीको गुणस्तरका लागि सामुदायिक प्रयास**

Working with communities to demonstrate and disseminate methods for improving drinking water quality using structural and vegetative measures

The People and Resource Dynamics in Mountain Watersheds of the Hindu Kush-Himalayas Project (PARDYP) implemented this approach with 30 drinking water user households at Barbot in the Jhikhu Khola watershed, Kabhre Palanchok. The aim was to improve water quality and availability from an open spring source through participatory planning and implementation.

The approach first identified local concerns and observed the sanitary situation of the catchment area. Meetings were held jointly with men and women users from different caste groups (Brahmin, Chhetri, Newar and Kami) to discuss the problems and issues and to identify viable solutions. The advantages and disadvantages of the various options were discussed, after which users selected the following three measures to improve the drinking water supply: 1) building a brick-cement walled structure around the main local spring, 2) establishing check dams across nearby rills and gullies, and 3) planting grass around the spring box and tree saplings within the catchment area. The aim was to prevent direct flow of surface water into the spring and reduce contamination and turbidity of the source. Understanding and support was gained by demonstrating the technology and running an awareness campaign.

The project helped form a users committee made up of 11 women and 1 man and encouraged them to plant grass and tree seedlings across the entire catchment. The project regularly measured the quality of the water and shared the results with the users. Rules and regulations were developed to ensure equitable access to the spring and its sustainable use and management. A notice board with do's and don'ts was placed near the spring. The users held monthly meetings and established a revolving fund for maintaining the structures.

Spring users followed the rules and regulations by washing, cleaning, and bathing at separate sources. Livestock grazing was stopped in the nearby area and the area was regularly cleaned. Furthermore, users were encouraged to treat water for drinking using simple methods like SODIS and the low cost Safa filter to avoid microbiological contamination. They were made more aware of water quality, sanitation, and health issues.

WOCAT database reference: QA NEP17
Location: Barbot-Dhotra, Jhikhu Khola watershed, Kabhrepalanchok, Nepal
Approach area: <0.1 km^2
Land use: Extensive grazing
Climate: Humid subtropical
Related technology: Drinking water quality improvement through conservation measures (QT NEP17)
Compiled by: Madhav Dhakal, ICIMOD
Date: October 2006

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

Problem, objectives and constraints

Problem
- Weak institutional collaboration to develop technological options for improving drinking water quality and availability and to raise awareness on health and hygiene and waterborne diseases

Objectives
- To explore and demonstrate appropriate water quality improving technologies and methods in a participatory way
- To increase awareness on water quality, water treatment, and health and hygiene
- To share knowledge gained on the water improvement options with farmers and other stakeholders

Constraints addressed

Major	Specification	Treatment
Technical	Different water treatment methods	Awareness of structural and vegetative measures; direct water treatment methods including Safa filter, SODIS, chlorination
Institutional	Weak institutional collaboration	User group formed linking local community organisations
Minor	**Specification**	**Treatment**
Financial	For the maintenance of the implemented technology	Revolving fund collected by users

Participation and decision making

Target group

Land users

Approach costs met by:

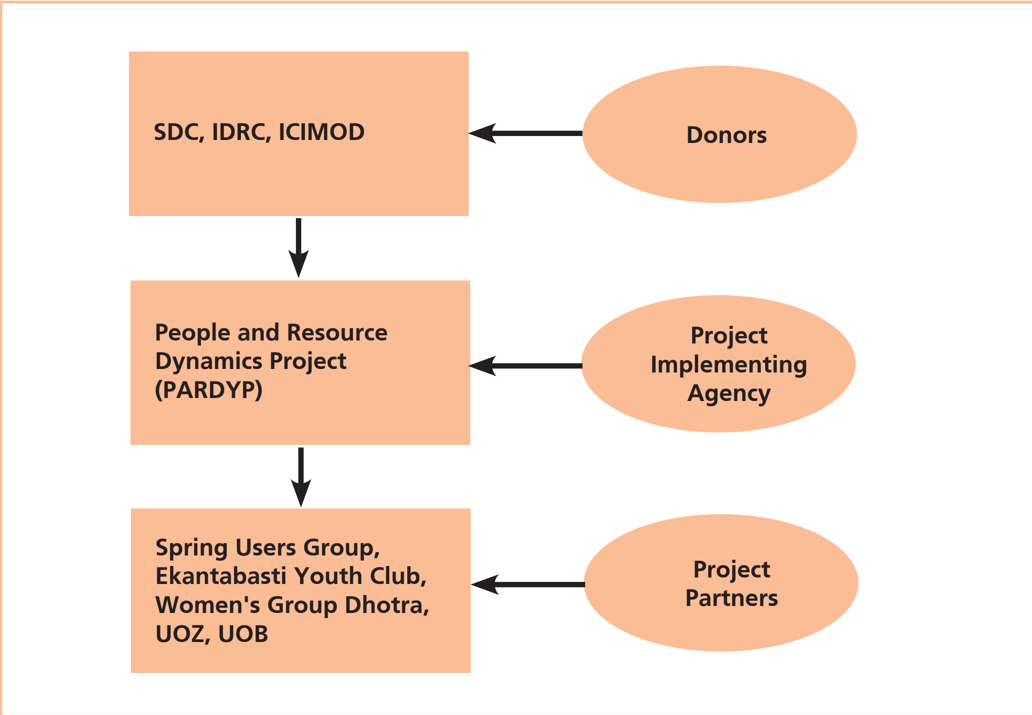
International donor funded project (PARDP)	90%
Community/local	10%
TOTAL	**100%**

Decisions on choice of the technology: Mainly land and water resource users including women supported by a soil and water conservation (SWC) specialist. Users selected three of the potential conservation options.
Decisions on method of implementing the technology: Mainly land users supported by SWC specialist. The technology and associated measures were not new to the area and the implementing methods were simple and have been practised for a long time. The project initiated the formation of a users committee and the committee conducted the conservation activities.
Approach designed by: National specialist (project staff) together with the villagers. Concept designed by national specialist and implemented jointly with users

Community involvement

Phase	Involvement	Activities
Initiation	Interactive	Public meetings organised to identify problems and possible options to overcome them
Planning	Interactive	Public meetings organised regularly to identify implementing steps, and role and responsibility of different stakeholders in overcoming problems
Implementation	Self-mobilisation	Shared responsibility for major steps with the user group responsible for implementation and the project for technical support
Monitoring/ evaluation	Interactive	The quality of the water was measured in each season to monitor the impact of the technology. Detailed progress reports, results, and lessons learned were shared with district level institutions and authorities, water quality reports were shared with spring users at public meetings
Research	Passive	Water quality and availability recorded before and after technology implemented. Studies on access to water and conflicts among users

Differences in participation of men and women: None both participated equally



PARDP project donors and implementing partners
SDC: Swiss Agency for Development and Cooperation
IDRC: International Development Research Centre
ICIMOD: International Centre for Integrated Mountain Development
UOZ: University of Zurich
UOB : University of Bern

Extension and promotion

Training: Before implementation, users were trained on conservation measures and methods of treating contaminated water using SODIS and Safa filter. Information, education, and communication materials were used. The training was effective, especially for improving water quality.
Extension: After the technology was implemented, a number of exchange, interaction, and monitoring programmes were run to promote and scale up the technology. Multiple stakeholder involvement in these programmes helped to evaluate the success of the technology. All users have benefited from the training and their raised awareness of soil and water conservation.
Research: Some ad hoc research was carried out by the PARDYP project on access to drinking water, conflicts at water fetching times, water quality and quantity measurement, and effectiveness of water treatment methods.
Importance of land use rights: The land use rights – mostly state owned land and some private – did not hinder the implementation of the technology.

Incentives

Labour: Land users' involved as volunteers in implementing the technology and the approach
Inputs: Planting materials
Support of local institutions: Training on water quality treatment provided to local club
Long-term impact of incentives: The incentives in the long term helped greatly in conserving the spring sources and there are clear positive environmental and health hygiene effects.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Biophysical	ad hoc observation on land use and degradation, sanitary inspection, history of spring, and available sources to trap water
Technical	regular measurement of seasonal water quality, and discharge
Socio-cultural	ad hoc observation on number of spring users (dependent, regular, occasional), household water requirement, and users' issues
No. of land users involved	observation of users' participation in conservation activities

Impacts of the approach

Changes as a result of monitoring and evaluation: Few changes were made – the project consulted with the local women's cooperative to solve a conflict over water quantity and access to the spring source
Improved soil and water management: Approach helped greatly to build awareness on SWC and methods of improving drinking water quality. It also helped users to work in a group
Adoption of the approach by other projects/land users: Similar approaches were already followed in other communities across Nepal
Sustainability: Users are maintaining the implemented technology and also protecting the other nearby spring sources

Concluding statements

Strengths and ➔how to sustain/improve	Weaknesses and ➔how to overcome
Users have become more aware of sanitation issues than before ➔ Awareness campaigns should be organized regularly covering more villages	Conflicts are visible during the dry season due to insufficient quantity of water ➔ Good coordination among group members should minimise conflicts – the strong and balanced role of the users committee is vital for the equitable sharing of benefits
Users have become more aware of 1) the quality of their drinking water, 2) its impact on their health, 3) water quality improvement options, and 4) the importance of soil and water conservation ➔ Water quality testing campaigns should be continued and technical know how about different water quality treatment methods for improved health shared at regular meetings	
Water users committee formed, revolving fund collected, and rules and regulations developed for the sustainable management of the drinking water system ➔ Maintain links with local community mobilisation groups for continuous guidance and support for the user group and for the proper use of the revolving fund	

Key reference(s): ICIMOD (2007) *Good Practices in Watershed Management, Lessons Learned in the Mid Hills of Nepal.* Kathmandu: ICIMOD
Contact person(s): HIMCAT/WOCAT Coordinator, International Centre for Integrated Mountain Development (ICIMOD), GPO Box. 3226, Kathmandu, Nepal, himcat@icimod.org

Left: Urine collection channel (Kiran Ghising)
Right: Collected urine in a plastic vessel (Juerg Merz)

Improved cattleshed for urine collection

Nepal: मूत्र संकलनका लागि सुधारिएको गोठ

Collection of cattle urine in improved cattle sheds for use as liquid manure and organic pesticide

Nitrogen is the most important macronutrient for plants, and high crop productivity can only be achieved by making sufficient nitrogen available to crops. Nitrogen is also the most limiting nutrient in farms across Nepal's midhills. Traditionally farmers applied farmyard manure to fertilise their needs. In many places this is being supplemented or even entirely replaced by inorganic fertiliser – mainly urea. The price of inorganic fertiliser has increased continuously in recent years and it is only available in limited quantities in areas far from the roadheads. On the other hand, cultivation practices are intensifying with increased cropping intensities and more nutrient-demanding crops as, for example, local varieties are replaced by hybrids and new crops are grown. This can easily lead to declining soil fertility and nutrient mining if it is not compensated for by an equivalent increase in organic or mineral fertilisation.

Cattle urine is a viable alternative to mineral fertiliser. Of the nitrogen excreted by cattle, 60% is found in the urine and only 40% in dung. In traditional sheds, urine is left to be absorbed in the bedding material, while excess urine is channelled out of the shed and disposed of. The technology described here – improved cattle sheds – are designed for collecting the urine in a pit or drum. This pit is generally located in the shed itself or just outside connected to the drainage channel through a pipe and protected from rain and runoff. Where urine is collected for incorporation in farmyard manure, the pit may be directly connected to the manure pit or heap. Urine that is going to be used as liquid manure or organic pesticide has to be stored in a drum for fermentation.

A household with two cattle can save the equivalent of purchasing about 100 kg of urea over one year by applying urine either directly as liquid fertiliser or as a component in improved farmyard manure.

The Sustainable Soil Management Programme (SSMP) implements its projects in several midhills districts of Nepal
(dark green: previous working districts;
light green: districts in 2007)

WOCAT database reference: QT NEP1
Location: Nepal midhills
SWC measure: Management
Land use: Annual cropping on rainfed agricultural land
Climate: Humid subtropical
Related approach: Farmer- to-farmer diffusion (QA NEP1); Farmer-led experimentation (QA NEP3); Farmer Field school on integrated plant nutrient systems (QA NEP4)
Compiled by: SSMP
Date: January 2007

The Sustainable Soil Management Programme is implemented by Helvetas Nepal and Intercooperation in collaboration with the Government of Nepal and civil society actors. It is financed by the Swiss Agency for Development and Cooperation. The technology was documented using the WOCAT (www.wocat.org) tool.

Classification

Land use problems

Intensifying cultivation practices with either 1) inadequate application of fertilisers leading to a decline in soil fertility and the mining of soil nutrients or 2) application of too much fertiliser causing environmental problems through excessive leaching, and losses of fertiliser in surface runoff and consequent eutrophication or nitrification of streams, ponds, or groundwater.

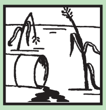
Land use

Annual crops; maize-wheat, potato, mustard, different types of vegetables

Climate

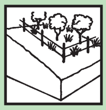
Humid subtropical

Degradation



Chemical degradation; soil fertility decline, soil nutrient mining

SWC measures



Management: collection of urine, rather than its disposal

Technical function/impact

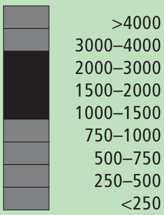
Main:
- organic manure
- increase in soil fertility
- increase in soil productivity
- pest control

Secondary:
- supplementary irrigation

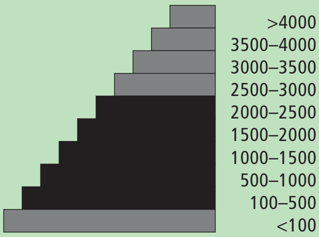
Environment

Natural environment

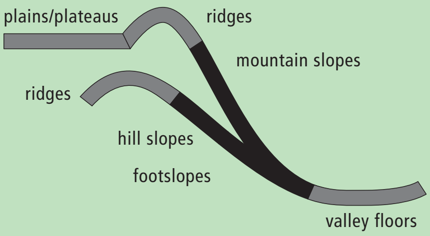
Average annual rainfall (mm)



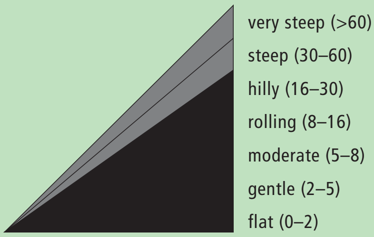
Altitude (masl)



Landform



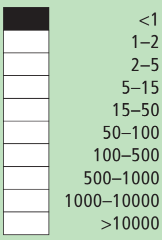
Slope (%)



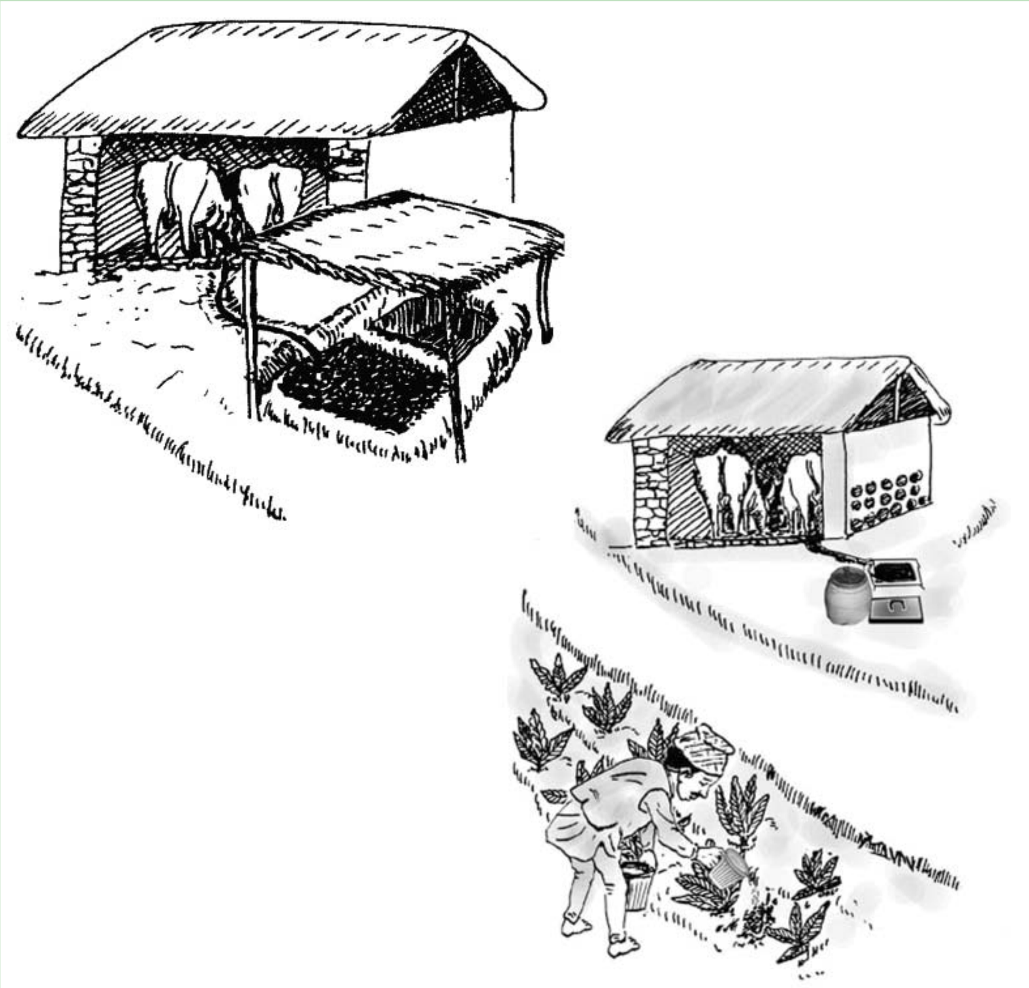
Applied Potential

Human environment

Cultivated land per household (ha)



Land use rights: individual, leased (sharecropping between owner and tenant)
Land ownership: individually owned, titled and not titled
Market orientation: subsistence, commercial, and mixed (subsistence/commercial)
Level of technical knowledge required: low
Number of livestock: poor households usually have some goats and one cow or buffalo, wealthier households often own several cattle, buffaloes, and a pair of oxen for ploughing.
Importance of off-farm income: in most farm households, off-farm income plays at least a minor and increasingly a major role. Occasional opportunities for off-farm income present themselves in the form of daily labour wages. Some households' members receive regular salaries, whilst an increasing number of Nepalis are working in India, the Middle East, Malaysia, and elsewhere and sending remittance incomes home.



Technical drawing
a) Urine collection and direct incorporation in covered farmyard manure pit.

b) Urine collection for later application as liquid manure or organic pesticide.

Implementation activities, inputs and costs

Establishment activities

1. Provide slight slope to the cattle shed floor
2. Dig a draining ditch and a collection pit, if possible at the lowest point inside the shed. If this is not possible, an outside pit should be dug, protected from rain and runoff, and connected with the draining ditch through a pipe or a channel.
3. Make the floor as impermeable as possible; e.g. with cement (expensive and durable), stone slabs, soil compaction, or clay (cheap but not durable). The more impermeable the floor, the more urine can be collected.
4. Provide a jug/'decapitated' plastic bottle/cup/etc. to scoop the urine out of the collection pit into the fermentation drum.

Duration of establishment: < 1 week

Establishment inputs and costs per shed (average)

Inputs	Cost (US$)[1]	% met by land user
Labour (3 days)	6	100%
- Plastic drum	6	0-100%
TOTAL	**12**	**0-100%**

(~ about 30 kg urea)[2]

[1] Exchange rate US$1 = NRs 67 in January 2007 [2] At the rate of NRs 1400 per 50 kg urea

Maintenance/recurrent activities

1. When the collection pit is full, the collected urine has to be removed from the pit and stored in a plastic drum for fermentation.
2. The urine is applied as liquid fertiliser by jug or through drip irrigation.

Maintenance/recurrent inputs and costs per system per year (2006)

Inputs	Cost (US$)	% met by land user
Labour (10 minutes/ day)	negligible	100%
TOTAL	**negligible**	**100%**

Remarks: It is clear that cattle or buffaloes are required for urine production. To help farmers to use their own resources, it is suggested to start with the cheapest and simplest form of urine collection and a compacted sloping floor and a collection pit within the shed. This allows the farmer to see the benefits of collecting the urine and will encourage them to invest in more expensive materials to improve the efficiency of urine collection.

Assessment

Acceptance/adoption

Setting up a system for collecting urine is generally linked with the relatively costly job of making improvements to a cattle shed. Approximately 30% of farmers who had participated in SSMP-supported programmes and were questioned during an impact assessment had adopted the technology. At the same time about 15% of farmers who were not members of SSMP-supported groups had also adopted the technology.

Drivers for adoption

- local resource, reduced costs for fertilisers
- simplicity of method
- impact on crop productivity
- pest control

Constraints to adoption

- cost of materials, plastic drum, cement, etc.; note that the provision of a plastic drum by the programme proved to be a disincentive for wider adoption as farmers outside the supported groups waited for a free drum before adopting the technology
- where resident housing was in a state of disrepair, owners wanted first to repair their houses before improving their cattle sheds (mainly in the Far Western Development Region)
- high establishment costs if cement is used

Benefits/costs according to land users

The high cost of mineral fertiliser means that the establishment costs are soon recovered. In the long-term, the major reduction in fertiliser cost leads to increased benefits.

Benefits compared with costs	short-term	long-term
establishment	positive	positive
maintenance/recurrent	positive	positive

Impacts of the technology*

Production and socioeconomic benefits

+ + +	Reduced expenses for agrochemicals (fertilisers, pesticides)
+	Easier shed management and cleaning
+	Improved animal health
+ +	Allows organic crop production

Production and socioeconomic disadvantages

- - -	High establishment costs if cement is used

Socio-cultural benefits

+	Social prestige as seen as progressive farmer

Socio-cultural disadvantages

-	Requires handling of dung and urine

Ecological benefits

+ + +	Reduced application of agrochemicals (fertilisers, pesticides), reduced eutrophication and nitrification of water bodies due to controlled outflow of urine

Ecological disadvantages

none

Off-site benefit

+ +	Reduction of dependence on outside inputs
+ +	Reduction of nutrient influx into water bodies

Off-site disadvantages

none

* All changes in technology may have gender and equity implications and potentially affect the members of disadvantaged groups differently. This has not been assessed here but should be considered when recommending technology use.

Concluding statements

Strengths and ➔how to sustain/improve	**Weaknesses** and ➔how to overcome
The use of urine collected on-farm reduced the requirement for mineral fertiliser which reduced production costs and outside dependency ➔ Further promotion of the technology will increase this impact	The initial costs incurred whilst improving a durable shed using cement may hinder adoption ➔Simpler methods such as using clay soil, compacting the floor, and using stone slates may, however lead to less urine being collected
Human urine can also be used to fertilise crops, but needs to be fermented longer and may be socially less accepted ➔ Promote the use of urine further and show there is no problem with using human urine	Project incentives (cement, plastic drum) have hindered adoption in some places ➔ No incentives should be provided, rather very simple methods should be demonstrated and adapted to local conditions
Applying urine as a liquid manure also irrigates the crops (fertigation) ➔ The link between urine application and drip irrigation, or other forms of small-scale irrigation, should be promoted. It has been tested and applied successfully by farmers related to SSMP in Syangja and Surkhet in western Nepal	Urine collection is feasible for subsistence farm households or small scale commercial producers. It may, however, not be applicable for larger scale commercial vegetable producers as a balance between area needed for livestock and growing the crops is needed ➔ Urine could become a tradeable commodity which would see large-scale livestock producers selling their urine to large-scale vegetable producers.

Key reference(s): STSS; SSMP (2001) *Farmyard Manure and Compost Management* (in Nepali). Kathmandu: Soil Testing Services Section, Department of Agriculture and Sustainable Soil Management Programme

Contact person(s): Director, Soil Management Directorate, Department of Agriculture, Harihar Bhawan, Lalitpur, +977 1 5520314 or
Team Leader, Sustainable Soil Management Programme (SSMP), GPO Box 688, Kathmandu/Nepal, +977 1 5543591 ssmp@helvetas.org.np

Left: Overview of improved terraces with soil and water conservation (SWC) grasses on riser margins. Maize was the major crop before the terraces were improved. Now vegetables and rice are grown. (K.M. Sthapit)
Right: Napier grass *(Pennisetum purpureum)* along the margins of an improved terrace riser. (K.M. Sthapit)

Improved terraces

Nepal: गह्रा सुधार

Hillside forward-sloping terracing and stabilisation using structural and vegetative measures

This technology addresses the soil erosion and water runoff problems associated with traditional outward-sloping terraces by reshaping the land into a series of level or gently sloping platforms across the slope. This technology is a variant of sloping land agricultural technology (SALT) or contour hedgerow technology. Nitrogen-fixing hedgerow species and quality fodder grass species, which bind the soil, are cultivated along terrace riser margins to improve terrace stability. This also enhances soil fertility and increases fodder availability. The plants are grown in either single or multiple layers. The practice is applied under rainfed conditions and is culturally acceptable and affordable. After establishment, the technology also addresses the problems of fodder scarcity making it easier and less time consuming for women and girls to gather fodder.

The hedgerow and grass species are established between January and June. Complete establishment of this technology may take one year. The first step in creating the terraces is to build retaining walls using cement bags filled with soil which are then supported with bamboo cuttings along the contour (= future terrace risers). This divides the land into the planned terrace sections. The length and width of the terraces depends on the size and shape of the original field. Secondly, the soil is excavated from the upper part of the terraces and is used to build up the lower part above and behind the terrace riser wall to create a level bed. The fertile top soil must be kept aside and later spread over the newly terraced fields. The final step is to plant grass and hedgerow species on the outermost margins of the terrace above the risers.

Maintenance involves slicing the terrace risers once or twice a year with a spade, and smoothing off rills that appear on the surface of terraces after the premonsoon and monsoon periods. Hedgerows should be cut regularly but not more than twice a year, normally to a height of about 50 cm. Grasses should be cut about once to twice a month depending on their rate of growth.

The technology is applied under humid subtropical climate conditions (1300 mm annual rainfall with about 80% of it falling in the monsoon months of June - September). The case study area has hill slopes of 16-30% that are mostly highly erodible red soils (FAO classification: luvisols).

WOCAT database reference: QT NEP2
Location: Kubinde village, Jhikhu Khola watershed, Kabhrepalanchok district
Technology area: 0.02 km^2
SWC measure: Structural and vegetative
Land use: Annual cropping
Climate: Humid subtropical
Related approach: Improving terraces with farmers, QA NEP2
Compiled by: Madhav Dhakal, ICIMOD
Date: February 2003, updated November 2006

General comments: Terrace improvement is an age old practice by which sloping hill land is mechanically converted into a series of level or nearly level terraces. It is commonly found in low to middle elevation ranges under both irrigated and rainfed conditions. However, the practice of riser stabilisation through vegetative means is not common.

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

Classification

Land use problems

The major land use problem in the area documented is the small per capita cropping landholding size. The fields are mostly rainfed and have low soil fertility and acidity problems and are susceptible to erosion. The high intensity of rainfall leads to considerable soil loss (rill and gully erosion) at the beginning of rainy seasons.

Land use

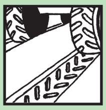
Annual crops: maize (before SWC applied), vegetables and rice (after SWC)

Climate

Humid subtropical

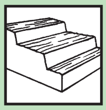
Degradation

Water erosion: loss of top soil, gullying

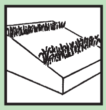


Physical degradation: soil moisture problem

SWC measures



Structural: reshaping surface, building walls



Vegetative: grasses/ hedgerow spenes/shrubs along risers

Technical function/impact

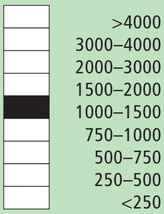
Main:
- reduction of slope angle
- reduction of slope length
- control of concentrated runoff (impedes/retards)

Secondary:
- increase in soil fertility
- increase/maintenance of water stored in soil
- increase of infiltration

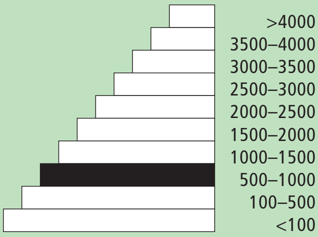
Environment

Natural environment

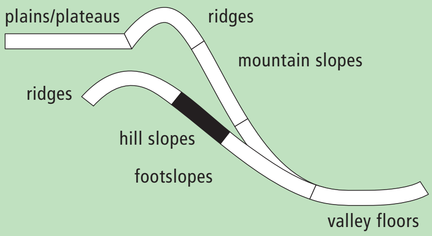
Average annual rainfall (mm)



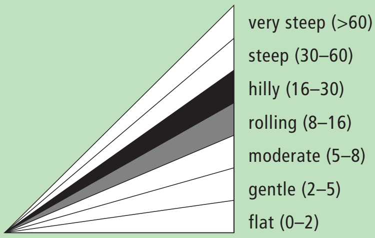
Altitude (masl)



Landform

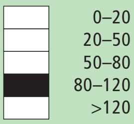


Slope (%)



Applied (large extent) Applied (medium extent)

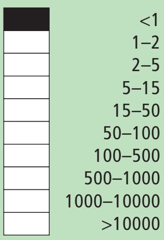
Soil depth (cm)



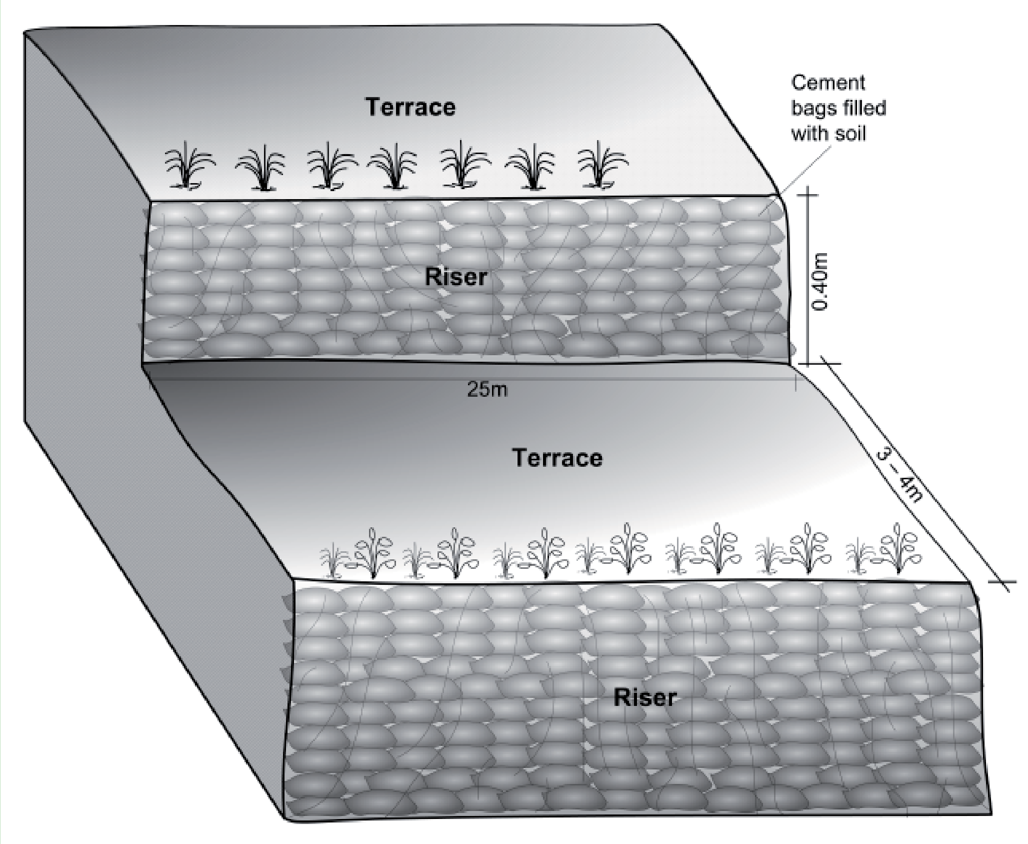
Growing season: 150 days (June to October) and 120 days (November to February)
Soil fertility: low
Soil texture: mostly fine (clay)
Surface stoniness: no loose stones
Topsoil organic matter: low to medium
Soil drainage: good
Soil erodibility: very high

Human environment

Mixed land per household (ha)



Land use rights: individual
Land ownership: individually owned/titled
Market orientation: mostly subsistence (self-supply), mixed (part subsistence and part commercial vegetable growing)
Level of technical knowledge required: field staff/extension worker: high, land user: moderate
Number of livestock: not relevant
Importance of off-farm income: In most farm households off-farm income plays at least a minor and increasingly a major role. Occasional opportunities for off-farm income present themselves in the form of daily labour wages. Some households' members receive regular salaries whilst an increasing number of Nepalis are working in India, the Middle East, Malaysia, and elsewhere and sending remittance incomes home.



Technical drawing
Schematic view after intervention [terracing and vegetative measures]
Riser slope: 75^0
Terrace slope: ~ 2^0

Implementation activities, inputs and costs

Establishment activities

Manual labour and local agricultural tools are used to establish this technology. The technology is best established between January and June although complete establishment may take one year. The major steps are as follows.

1. Establishment of risers, using cement bags filled with soil and planting bamboo cuttings for terrace stabilisation.
2. Terrace levelling: The length and width of the terraces depends on the size and shape of the field. Excavate soil from the upper part of the terrace field and use it to build up the lower part behind the terrace riser wall to create a level platform/bed.
3. Planting of grasses and hedgerow species on the outward margins of the terrace fields above the risers.

Establishment inputs and cost per ha (2003)

Inputs	Cost (US$)	% met by land user
Labour (312 person days)	970	50%
Technician	10.5	0%
Equipment		
- Tools (spade, shovel)	92	100%
Materials		
- Empty cement bags (1600)	80	50%
- Bamboo cuttings (80)	80	50%
Agricultural		
- Grass seeds (2kg)	25	0%
- Grass seedings (2500)	30	0%
TOTAL	**1287**	**51%**

Maintenance/recurrent activities

1. Surface and riser maintenance: smooth the surface/rills on the terrace field caused by monsoon and pre-monsoon rainfall. Terrace risers are sliced once or twice a year. All activities are performed manually using local agricultural tools like spades.
2. Hedgerow/grass maintenance: Hedgerows are cut regularly but not more than twice a year, normally a height of 50 cm is maintained. Grass is cut once or twice a month.

Maintenance/recurrent inputs and cost per ha per year (2003)

Inputs	Cost (US$)	% met by land user
Labour (100 person days)	310	100%
Equipment	20	100%
-		
Materials		
-		
Agricultural		
- Grass seeds (0.5kg)	6	100%
- Grass seedings (500)	6	100%
TOTAL	**342**	**100%**

Remarks: All costs and amounts are roughly estimated by the technicians and authors. Exchange rate US$1 = NRs 73 in 2006.

Assessment

Acceptance/adoption

Among 16 land user households, 6 households accepted the technology with incentives (about 50% subsidy from the project) and 10 households adopted it without any incentives. About 40% of the total land (0.02 km^2) was improved with subsidy being provided and 60% spontaneously.
The number of farmers applying the technology is increasing without further incentives. Others have shown interest in the technology but have not implemented it.

Drivers for adoption

- The technology addresses the direct needs of farmers of better land fertility, more crop and fodder production, and better retention of soil moisture.
- Technical support from projects and line departments
- Financial or material help for technology establishment

Constraints to adoption

- High cost of establishing the technology
- Farmers are not trained on all aspects of the technology
- Lack of incentives for poor farmers

Benefits/costs according to land users

The initial investment is high, but can be recovered within a short period due to yield increment and cash crop production.

Benefits compared with costs	short-term	long-term
establishment	equal	positive
maintenance/recurrent	positive	very positive

Impacts of the technology*

Production and socioeconomic benefits

+++	Increased yield of maize crop by 100%.
++	Increased farm income by >100% due to higher yields and incorporation of market-orientated crops
++	Increased fodder production/quality

Production and socioeconomic disadvantages

-	Loss of land

Socio-cultural benefits

+	Strengthened community institution: formed terrace user group

Socio-cultural disadvantages

none

Ecological benefits

+++	Reduced soil loss due to levelled surface and hedgerow barrier
+++	Improved soil cover along risers
++	Increased soil moisture
++	Increased soil fertility near hedgerows
++	Enhanced biodiversity due to new crop/vegetable species

Ecological disadvantages

-	Appearance of pests like rats due to introduction of planted grasses like Napier grass

Off-site benefit

++	Fodder grass multiplication through farmer to farmer dissemination
+	Reduced downstream flooding
+	Reduced downstream siltation

Off-site disadvantages

-	Less nutrients downstream

* All changes in technology may have gender and equity implications and potentially affect the members of disadvantaged groups differently. This has not been assessed here but should be considered when recommending technology use.

Concluding statements

Strengths and ➔how to sustain/improve

- Land productivity increased, maize, potato and bean production increased, vegetables and rice production started ➔ Irrigation facility could increase the production capacity of the terraces
- Availability of grass/fodder (nitrogen fixing) increased. ➔ Planting horticultural fruits could increase farm incomes and so it should be promoted and more nitrogen fixing species (preferably local) should be tried out
- The price of land increased considerably from NRs 30,000 in 2001 (for 1 ropani – 508.5 sq. m) to between NRs 100, 000 and NRs 150,000 per ropani after the technology was established ➔ The price would increase further if irrigation facilities were installed
- The area of levelled terraces nearly doubled in Kubinde village from 2001 to 2003, which is an indicator of increased awareness of the benefits of soil and water conservation ➔ Experience sharing would help expand the area under improved terraces

Weaknesses and ➔how to overcome

- In the first year of implementation, maize production was reduced due to soil amendment ➔ a phenomenon which is likely to occur with new terrace formation
- Presently the vegetative technology is confined to terrace margins ➔it should be extended to the risers also

Key reference(s): ICIMOD (2002) *Hydro-meteorological Year Book of Jhikhu Khola Watershed.* Kathmandu: ICIMOD ■ Mathema, P.; Singh, B.K. (2003) *Soil Erosion Studies in Nepal: Results and Implications.* Kathmandu: Government of Nepal, Department of Soil Conservation and Watershed Management ■ Mathema, P. (2003) *Watershed Management in South Asia.* Kathmandu: Government of Nepal, Department of Soil Conservation and Watershed Management
Contact person(s): HIMCAT/WOCAT Coordinator, International Centre for Integrated Mountain Development (ICIMOD), GPO Box 3226, Kathmandu, Nepal, himcat@icimod.org

Left: Legumes (here peas) used as a relay crop. (Juerg Merz)
Right: Legumes (here pigeon pea) on terrace risers. (Juerg Merz)

Legume integration

Nepal: बाली प्रणालीमा कोसेवाली समावेश

Integration of leguminous crops as intercrops on terrace risers or as relay crops

Legumes are widely grown across the hills of Nepal, with the most common being soybean, lentils, black gram, cow pea, beans, horse gram, field peas, and rice bean. They are mostly intercropped or relay cropped with cereals such as maize, millet, and rice. They are also planted on the edges of terraces and rice paddy bunds. Depending on the species, they may be grown in rain-fed or irrigated fields during the winter or summer seasons.

The majority of the legumes grown by farmers are used for food or as a cash crop. The planting of fodder legumes has become more popular with the expansion of stall-feeding and the development of a dairy industry. The planting of legumes, with the main objective of improving soil fertility is a more recent development in Nepal's hills.

Nitrogen is the main plant nutrient element and is usually applied through commercial fertiliser where available. Legumes fix atmospheric nitrogen through bacterial nodules on their roots, then nitrogen subsequently becomes available to the following crops. It is important, therefore, not to uproot the legume crop during harvesting - it should be harvested by cutting the above ground parts leaving the roots (and the nodules) in the soil. The crop residues can be fed to livestock, used as animal bedding, applied as green manure directly to fields, or incorporated in compost. In this way most of the nitrogen that was fixed by the legume crop is returned to the soil.

Details about the different legume species and their different characteristics and uses are described in detail in SSMP, PARDYP and SSD-NARC (2000).

The Sustainable Soil Management Programme (SSMP) implements its projects in several midhills districts of Nepal (dark green: previous working districts; light green: districts in 2007)

WOCAT database reference: QT NEP3
Location: Nepal midhills
SWC measure: Agronomic
Land use: Annual cropping on rainfed agricultural land
Climate: Humid subtropical
Related approach: Farmer-to-farmer diffusion (QA NEP1), Farmer-led experimentation (QA NEP3), Farmer field school on integrated plant nutrient systems (QA NEP4)
Compiled by: SSMP
Date: January 2007

The Sustainable Soil Management Programme is implemented by Helvetas Nepal and Intercooperation in collaboration with the Government of Nepal and civil society actors. It is financed by the Swiss Agency for Development and Cooperation. The technology was documented using the WOCAT (www.wocat.org) tool.

Classification

Land use problems

Intensifying cultivation practices with either 1) inadequate application of fertilisers leading to a decline in soil fertility and the mining of soil nutrients or 2) the application of too much fertiliser causing environmental problems through excessive leaching, losses of fertiliser in surface runoff, and consequent eutrophication or nitrification of streams, ponds, or groundwater.

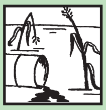
Land use

Annual crops; maize-wheat, potato, mustard, different types of vegetables

Climate

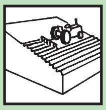
Humid subtropical

Degradation



Chemical degradation; soil fertility decline, soil nutrient mining

SWC measures



Agronomic; introduction of a new crop

Technical function/impact

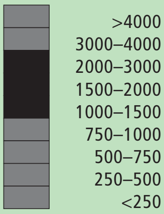
Main:
- increase in soil fertility (nitrogen in particular)
- increase in soil productivity
- nutritious and high value crop
- decrease in soil erosion on terrace bunds

Secondary:
- fodder or green manure
- income

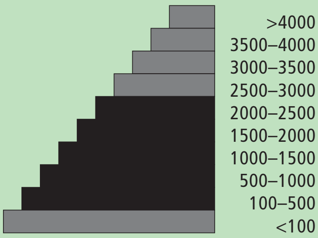
Environment

Natural environment

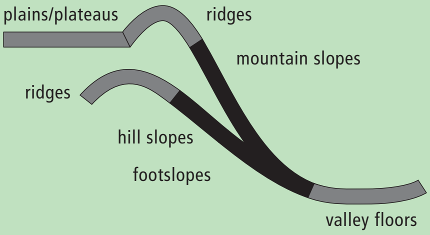
Average annual rainfall (mm)



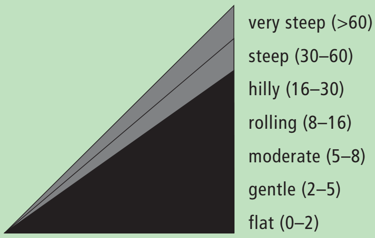
Altitude (masl)



Landform



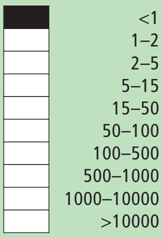
Slope (%)



Applied   Potential

Human environment

Cultivated land per household (ha)



Land use rights: individual, leased (sharecropping between owner and tenant)
Land ownership: individually owned, titled, and not titled
Market orientation: subsistence, commercial, and mixed (subsistence/commercial)
Level of technical knowledge required: low
Number of livestock: Poor households usually have some goats and one cow or buffalo. Rich households often own several cattle, buffaloes, and a pair of oxen for ploughing.
Importance of off-farm income: In most farm households, off-farm income plays at least a minor and increasingly a major role. Occasional opportunities for off-farm income present themselves in the form of daily labour wages. Some households' members receive regular salaries whilst an increasing number of Nepalis are working in India, the Middle East, Malaysia and elsewhere and sending remittance incomes home.

Technical drawing
A number of species are presented in the legume integration decision support guide (SSMP, PARDYP, SSD-NARC 2000). Here only a selection of useful legume species are presented (from top left corner to lower right corner):
- red clover *(Trifolium pratense)*
- hairy vetch *(Vicia villosa Roth)*
- Chinese milk vetch *(Astragalus sinicus)*
- rice bean *(Vigna umbellata)*
- velvet bean *(Mucuna pruriens)*
- tephrosia *(Tephrosia spp.)*

Implementation activities, inputs and costs

Establishment activities

1. Depending on the type of farm niche - broadcast, line sow, or spot plant the appropriate species during the appropriate season (for more information refer to Training Manual and Decision Guide) (SSMP, 2005; SSMP, PARDYP, SSD-NARC, 2000)

Duration of establishment: < 1 day

Establishment inputs and costs per ropani (= 1/20 ha)

Inputs	Cost (US$)[1]	% met by land user
Seeds (2–3 kg)	1 - 2	100%
Labour (~2-3 days)	4 - 6	100%
TOTAL	**5 - 7**	**100%**

[1] Exchange rate as per January 2007 US$1 = NRs 67

Maintenance/recurrent activities

1. None required

Maintenance/recurrent inputs and costs per ha per year

Inputs	Cost (US$)	% met by land user
TOTAL		

Assessment

Acceptance/adoption

The value of integrating legumes in cropping cycles is well understood by most farmers and about 80% of participating farmers used/had adopted this simple and inexpensive technology. It has also been adopted by farmers who have not directly participated in SSMP activities, by learning from their neighbours and peers. While this is not a new technology, farmers now consciously plan a legume crop for improved soil fertility.

Drivers for adoption

- Inexpensive technology
- Provides an additional high value or nutritious crop
- Reduces fertiliser requirements

Constraints for adoption

- Seed of some species may not be readily available

Benefits/costs according to land users

On average a benefit of US$ 40 to 50 per ropani can be expected from the production of legume species

Benefits compared with costs	short-term	long-term
establishment	positive	positive
maintenance/recurrent	positive	positive

Impacts of the technology*

Production and socioeconomic benefits

+++	Reduced expenses for nitrogen fertilisers
+	Additional high value and nutritious crop
+	Nutritious livestock fodder

Production and socioeconomic disadvantages

- -	Risky crop in terms of main yield

Socio-cultural benefits

none

Socio-cultural disadvantages

none

Ecological benefits

+++	Reduced application of nitrogen fertilisers
+	Reduced soil erosion
+	Increase in organic matter

Ecological disadvantages

- -	Highly susceptible to diseases and pests

Off-site benefit

++	Reduced outside dependency
++	Reduced nutrient influx into water bodies

Off-site disadvantages

none

* All changes in technology may have gender and equity implications and potentially affect the members of disadvantaged groups differently. This has not been assessed here but should be considered when recommending technology use.

Concluding statements

Strengths and ➔how to sustain/improve	**Weaknesses** and ➔how to overcome
Cost effective in terms of inputs and management practices in comparison with other commodities	Highly vulnerable to diseases and pests ➔ skip planting time (i.e. preponing planting of crops to get around life cycle of pests) , use location specific species, resistant varieties
Needs less agronomic practices and care (i.e. can be cultivated in zero or reduced tillage)	Very susceptible to waterlogging ➔only plant in well-drained soils
Has multiple uses: food crop, feed crop, fodder, soil building	In high fertility conditions, nitrogen fixing *rhizobium* does not work leading to less nitrogen fixation ➔ for very specific and new species, the soil needs to be inoculated with the correct strain of bacteria
Can be integrated in varying niches on farms and therefore does not need additional land	Legumes generally do not respond to nitrogen fertiliser ➔Do not apply nitrogen fertiliser to legumes
Rich indigenous knowledge exists	

Key reference(s): SSMP (2005) *Legume Integration Manual* (in Nepali). Kathmandu: Sustainable Soil Management Programme ■ SSMP; PARDYP; SSD-NARC (2000) *Legume Integration into Hill Farming Systems,* Decision Support Guide. Kathmandu: Sustainable Soil Management Programme, People and Resource Dynamics Project and Soil Science Division-Nepal Agricultural Research Council

Contact person(s): Director, Soil Management Directorate, Department of Agriculture, Harihar Bhawan, Lalitpur, +977 1 5520314 or
Team Leader, Sustainable Soil Management Programme (SSMP), GPO Box 688, Kathmandu/Nepal, +977 1 5543591, ssmp@helvetas.org.np

Left: Crop sprayed exclusively with botanical pesticides (Juerg Merz)
Right: Different plants soaked in cattle urine for later use as a botanical pesticide (Juerg Merz)

Organic pest management

Nepal: जैविक रोगकीरा व्यवस्थापन

Promotion of botanical pesticides for organic pest management and liquid manure

Production of fresh vegetable is often hampered by pests which may reduce production and badly affect farmers' income. Chemical pesticides are available and are used, sometimes excessively, to combat these pests in parts of Nepal's midhills. Botanical pesticides prepared from a variety of plant ingredients soaked and fermented in cattle urine provide a suitable alternative to chemical pesticides, at least for subsistence and semi-commercial vegetable producers. These pesticides are based on farmer's traditional knowledge and are emerging as alternatives to the application of chemical pesticides.

All the ingredients for these pesticides are available locally; in some cases the plants are considered as weeds. Crofton weed (banmara) grows in abundance along roads and paths, and on forest floors and suppresses the growth of other more valuable species. It is believed to have pesticidal effects and is often used in botanical pesticides. The Nepali names of other plants commonly used in the tonics are asuro (malabara tree), titepati (mugwort), bakaino (Persian lilac), timur (Nepali pepper), patina (field mint), tulsi (sweet basil), neem, sisnu (stinging nettle), ketuke (century plant), and khirro (tallow tree). In general it is said that herbs and plants that are bitter, pungent, or 'hot' or that produce a strong odour are most effective in botanical pesticides.

The botanical pesticide is diluted with water before applying to vegetable crops. The dilution ratio depends on the age and type of the plant being treated with a higher dilution for seedlings in nurseries than for mature plants. While botanical pesticides do not kill all pests, they do combat soft-bodied insects such as aphids and act as a repellent against larger insects like cutworms, various larvae, and red ants. They are not usually effective against plant diseases.

In some places innovative farmers have started to produce and sell botanical pesticides for pest management and as a liquid manure for foliar application.

The Sustainable Soil Management Programme (SSMP) implements its projects in several midhills districts of Nepal
(dark green: previous working districts;
light green: districts in 2007)

WOCAT database reference: QT NEP4
Location: Nepal midhills
SWC measure: Management
Land use: Annual cropping on rainfed agricultural land
Climate: Humid subtropical
Related approach: Farmer-to-farmer diffusion (QA NEP1); Farmer-led experimentation (QA NEP3); Farmer field school on integrated plant nutrient systems (QA NEP4)
Compiled by: SSMP
Date: January 2007

The Sustainable Soil Management Programme is implemented by Helvetas Nepal and Intercooperation in collaboration with the Government of Nepal and civil society actors. It is financed by the Swiss Agency for Development and Cooperation. The technology was documented using the WOCAT (www.wocat.org) tool.

Classification

Crop cultivation problems

Intensifying cultivation practices and the increasing demand for fresh and off-season vegetables have increased the incidence of pests. These pests are controlled mainly by chemical pesticides where available, and where they are not available entire crops can be destroyed and farmers' livelihoods endangered.

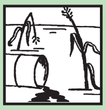
Land use

Annual crops: maize-wheat, potato, mustard, different types of vegetables

Climate

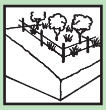
Humid subtropical

Degradation



Chemical degradation: soil fertility decline, soil nutrient mining

SWC measures



Management: replacement of chemical pesticides

Technical function/impact

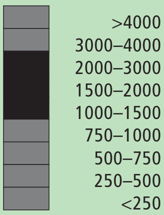
Main:
- reduction in pest incidence
- reduction in application of chemical pesticides
- reduction in application of chemical fertilisers

Secondary:
- supplementary irrigation

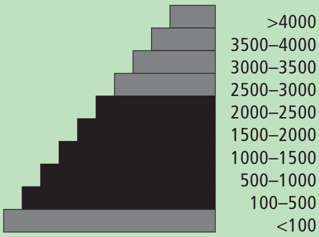
Environment

Natural environment

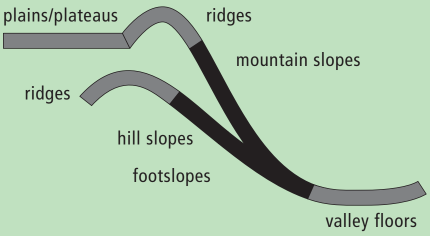
Average annual rainfall (mm)



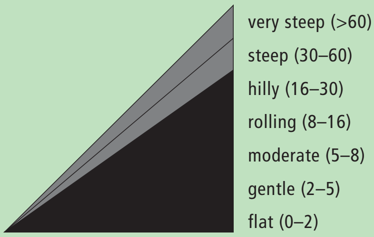
Altitude (masl)



Landform



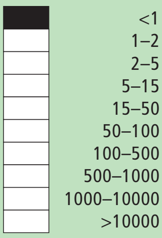
Slope (%)



Applied   Potential

Human environment

Cultivated land per household (ha)



Land use rights: individual, leased (sharecropping between owner and tenant)
Land ownership: individually owned, titled and not titled
Market orientation: subsistence, commercial and mixed (subsistence/commercial)
Level of technical knowledge required: low
Number of livestock: Poor households generally have some goats and a cow or buffalo. Rich households often own several cattle, buffaloes and a pair of oxen for ploughing.
Importance of off-farm income: In most farm households off-farm income plays at least a minor and increasingly a major role. Occasional opportunities for off-farm income present themselves in the form of daily labour wages. Some households' members receive regular salaries whilst an increasing number of Nepalis are working in India, the Middle East, Malaysia and elsewhere and sending remittance incomes home.

Technical drawing
The following plants are amongst many reported to have pesticidal value (from top left corner to lower right corner)
- sisnu *(Urtica dioica)*
- timur *(Zanthoxylum oxyphyllum)*
- titepati *(Artemisia vulgaris)*
- ketuke *(Agave americana)*
- banmara *(Eupatorium odoratum)*
- kantakari *(Solanum xanthocarpus)*
- bakaino *(Melia azedarach)*

A comprehensive list can be found in Neupane (2056 BS).

Implementation activities, inputs and costs

Establishment activities

1. Different plants with pesticidal properties are collected and chopped into small pieces. Only tender parts should be used to facilitate decomposition.
2. Other materials like ginger powder, green chilli, ash, and mustard cake are mixed with the chopped plant material.
3. The material is placed in a plastic drum or earthen pot and soaked in cattle urine at the rate of about one kilogramme of solid material per 2 litres of cattle urine.
4. The drum is closed as air-tight as possible and put in a shady place.

Preparation and set-up time: < 2 days

Establishment inputs and costs

Inputs	Cost (US$)[1]	% met by land user
Drum (20 l)	6	100%
Labour (2 days)	4	100%
TOTAL	**10**	**100%**

(~ gives equivalent to 650 ml of systematic poison to control aphids)[2]

[1] Exchange rate as of January 2007, US$1 = NRs 67, [2] at the rate of 1.5 US$ per 100 ml

Maintenance/recurrent activities

1. The botanical pesticide needs to be stirred with a wooden stick about every 15 days.
2. The prepared pesticide is normally ready for field application after about 35-40 days of fermentation/preservation.
3. The pesticide is diluted with water 1:4 (1 part pesticide solution: 4 parts water) for mature plants and 1:8 for nurseries and applied with a jug, sprayer, or broom.

Maintenance/recurrent inputs and costs per ha per year

Inputs	Cost (US$)	% met by land user
Labour	negligible	100%
TOTAL	**negligible**	**100%**

Assessment

Acceptance/adoption

The preparation and use of botanical pesticides has mainly been adopted by small to medium scale producers of fresh vegetables. A survey of farmers trained in preparing and applying botanical pesticides by SSMP found that 50% of them were producing and applying the pesticides themselves. Only 10% of local farmers from outside the SSMP groups were using the technology.

Drivers for adoption

- Inexpensive and simple technology based on locally available materials
- Based on traditional knowledge from local farmers
- Reduces expense of chemical pesticides
- Very effective against aphids

Constraints to adoption

- Time consuming preparation process
- Not effective for all kinds of pests – especially large insects – and not effective against plant diseases
- Variability of mixtures, not standardised, efficiency not guaranteed

Benefits/costs according to land users

Benefits compared with costs	short-term	long-term
establishment	positive	positive
maintenance/recurrent	positive	positive

Impacts of the technology*

Production and socioeconomic benefits

- +++ Reduced expenditure on agrochemicals (fertilisers, pesticides)
- ++ Decreased pest incidence and destruction of crops
- ++ Improved crop health due to additional fertiliser
- ++ Allows organic production of crops

Production and socioeconomic disadvantages

- -- Labour-intensive preparation of botanical pesticides
- -- Need to be prepared fresh for each crop, therefore demanding labour often at inconvenient times

Socio-cultural benefits

- + Increased social prestige as use shows user to be a progressive farmer

Socio-cultural disadvantages

- - May not be accepted due to urine in the mixture (especially if human urine is used)

Ecological benefits

- +++ Reduced application of agrochemicals (fertilisers, pesticides)
- +++ Improved soil biology health

Ecological disadvantages

- - May acidify the soil if not decomposed well

Off-site benefit

- ++ Reduction of dependence on costly external inputs
- ++ Reduction of chemical pesticide contamination of water bodies

Off-site disadvantages

none

* All changes in technology may have gender and equity implications and potentially affect the members of disadvantaged groups differently. This has not been assessed here but should be considered when recommending technology use.

Concluding statements

Strengths and ➔how to sustain/improve	**Weaknesses** and ➔how to overcome
Organic pest management using botanical pesticides reduce the expense of pest control ➔ Further promote the benefits of organic pest management	Labour intensive preparation often at inconvenient times as the botanical pesticide has to be prepared fresh for each crop and can only be stored for a limited amount of time ➔ Develop methods that reduce labour requirements and highlight possibilities for bulk production and adequate storage without losing effectiveness
Organic pest management reduces the negative impact of chemical pesticides ➔ Further promote the benefits of organic pest management	The reagents that are effective in the botanical pesticides have not been identified ➔ Carry out applied research into the different reagents and their effect on different pests
	The botanical pesticides are not effective against all pests ➔ Carry out applied research into and document the effects of different botanical pesticides on different pests

Key reference(s): Neupane, F.P. (2056 BS - 1999/2000) *Insect Control by Herbs.* Kathmandu: Sajha Publications ■ Several pamphlets on different tonal tonic compositions are available in Nepali from SSMP

Contact person(s): Director, Soil Management Directorate, Department of Agriculture, Harihar Bhawan, Lalitpur, +977 1 5520314 or
Team Leader, Sustainable Soil Management Programme (SSMP), GPO Box 688, Kathmandu/Nepal, +977 1 5543591 ssmp@helvetas.org.np

Left: A drip system irrigating bitter gourd seedlings – seedlings are generally transplanted in February-March when water availability is low (PARDYP)
Right: Bitter gourd and cauliflower under drip irrigation (PARDYP)

Low cost drip irrigation

Nepal: थोपा सिंचाई

An irrigation system which allows the slow and precise delivery of water to crops

Drip irrigation is a very water-efficient irrigation system. Water is dripped to individual plant root zones at low rates (2.25 l/hr) from emitters embedded in small diameter plastic pipes.

Farmers in the Jhikhu Khola watershed, Nepal, suffer from a shortage of water for irrigation between the end of one monsoon (June to September) and the next pre-monsoon period (May). This seriously limits agricultural production and leads to much land being left fallow after the monsoon crops have been harvested. Only a small area is planted with winter crops. The sources of irrigation water (such as rivers, and streams) are limited and the amount of water they provide is inadequate for cropping. Most of the sources remain dry outside the monsoon. Farmers expend considerable time and labour gathering what water they can to irrigate their crops. Low cost drip irrigation (LCDI) has been introduced in the watershed as a cost effective way of making the best use of the limited available water.

The cropping pattern of this area sees pre-monsoon vegetables established in February and March and winter vegetables in September and October. The low cost drip irrigation sets are installed while the fields are being prepared by ploughing, levelling, and ridging. Lateral pipes (12m long) are laid along the ridges which lie 1.5m apart. A wooden platform with storage tank is installed and connected to the lateral pipes. After the lateral pipes are laid out, planting holes are dug along the ridges spaced to coincide with the drip holes. These holes are usually set every 0.6 or 1.2m along the pipes depending on the crop. Farmyard manure and chemical fertiliser is placed in each pit and mixed well with the soil. Next, vegetable seedlings are planted in each hole and daily drip watering begins. Bitter gourd is the most commonly grown crop followed by cauliflower. Irrigation water is generally applied either in the morning or the evening. If needed, stakes are placed next to each plant a week later to allow the plants to climb. The climber crops like bitter gourd are netted one month after planting to provide more space for fruiting

Harvesting starts in mid-May and continues until September. Farmers maintain the system by repairing leaks in the pipe joints and by unblocking blocked drip holes.

WOCAT database reference: QT NEP6
Location: Kubinde village, Jhikhu Khola watershed, Kabhrepalanchok district
Technology area: ~ 0.1 km^2
SWC measure: Management
Land use: Annual cropping
Climate: Humid subtropical
Related approach: Participatory action research for drip irrigation, QA NEP6
Compiled by: Madhav Dhakal, ICIMOD
Date: August 2004, updated December 2005

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

Classification

Land/water use problems
Insufficient water limits agricultural production during the winter and pre-monsoon seasons (Nov-May) leading to low farm incomes from the small landholdings. The increasing inputs of chemical fertilisers are a matter of concern for environmental protection.

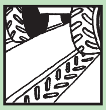
Land use

Annual crops: maize (before SWC),vegetables (after SWC)

Climate

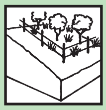
Humid subtropical

Degradation



Physical degradation: soil moisture problem

SWC measures



Management: from traditional irrigation to drip irrigation

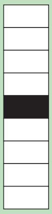
Technical function/impact
Main: - slow and precise delivery of water to plant root zones, enhanced photosynthesis
- increase or maintenance of soil moisture

Secondary: - reduction of evaporation losses
- reduction of water distribution losses

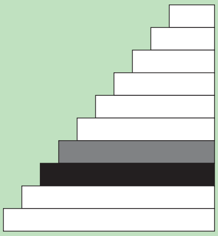
Environment

Natural environment

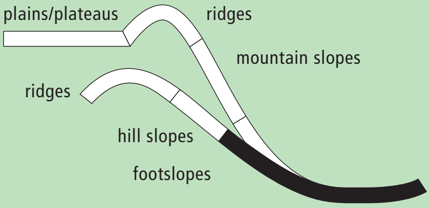
Average annual rainfall (mm)



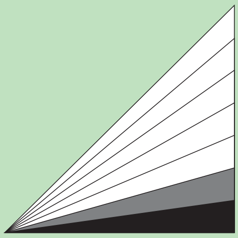
Altitude (masl)



Landform

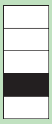


Slope (%)



Applied (large extent) Applied (medium extent)

Soil depth (cm)

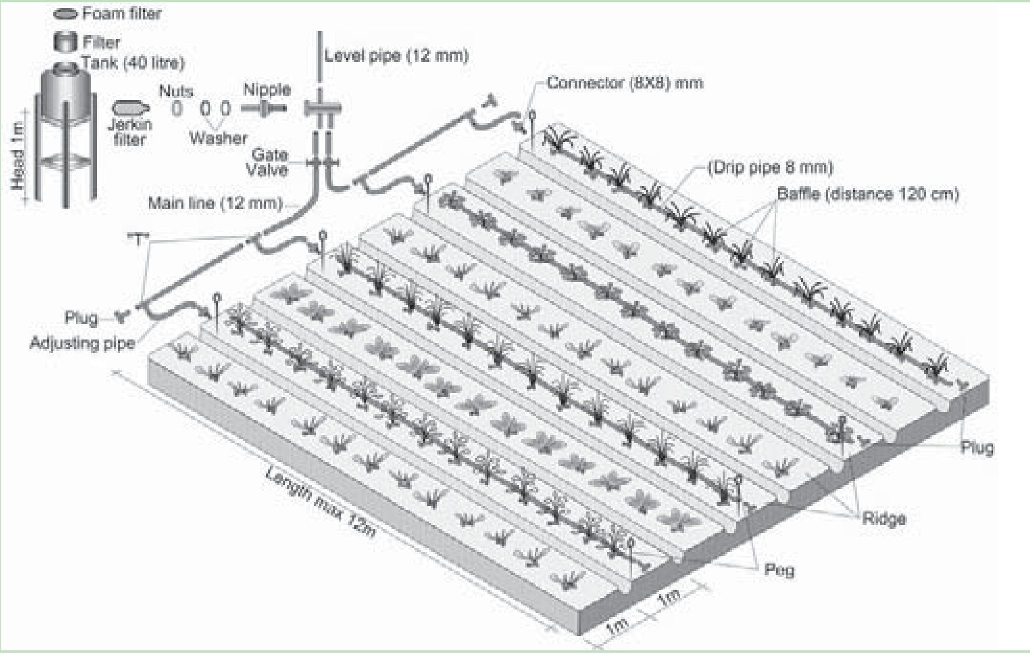


Growing season: 150 days (June to October) and 120 days (November to February)
Soil fertility: medium
Soil texture: mostly medium (loam)
Surface stoniness: no loose stones
Topsoil organic matter: low to medium
Soil drainage: good
Soil erodibility: mostly low

Human environment

Cropland per household (ha)

Land use rights: individual
Land ownership: individually owned/titled
Market orientation: mixed (subsistence and commercial), commercial vegetable growing
Level of technical knowledge required: field staff/extension worker: low, land user: moderate
Number of livestock: not relevant
Importance of off-farm income: in most farm households, off-farm income plays at least a minor and increasingly a major role. Occasional opportunities for off-farm income present themselves in the form of daily labour wages. Some households' members receive regular salaries, whilst an increasing number of Nepalis are working in India, the Middle East, Malaysia, and elsewhere and sending remittance incomes home.



Technical drawing
Technical parts and design of a low cost drip irrigation system (IDE-Nepal)

Implementation activities, inputs and costs

Establishment activities

The technology is established in February and March for pre-monsoon vegetables and September and October for winter vegetables, using manual labour and local agricultural tools like spades. The major steps are as follows.

1. Levelling of land for uniform water distribution
2. Construction of wooden platform to raise the storage tank generally 1m above the ground
3. Installation of lateral pipes along the ridges/beds; check the spacing of drip holes by turning on the system and noting where the drips fall, then dig about 0.5m deep and 0.3m diameter planting pits for the vegetable seedlings to coincide with the drip holes - usually every 0.6 or 1.2m along the pipes
4. Connection of the lateral pipes to the water storage tank
5. Opening and closing of gate valves

Establishment inputs and costs per unit system (2004)

Inputs	Cost (US$)	% met by land user
Labour (1 person day)	2.8	100%
Equipment	25.8	0%
TOTAL	**28.6**	**100%**

Maintenance/recurrent activities

Maintenance mostly involves repairing leaks in pipe joints and unblocking drip holes.

1. Prevent leakage by replacing damaged or worn out parts
2. Clean the drip holes with water and a pin

Maintenance/recurrent inputs and costs per unit per year (2004)

Inputs	Cost (US$)	% met by land user
Labour & spare parts	7	100%
TOTAL	**7**	**100%**

Remarks: In the first year, PARDYP provided a 100% subsidy on drip kits to demonstrate the technology. The next year only 50% of the capital costs were covered and after 2-3 years of demonstration the subsidy was withdrawn.
The above mentioned total cost was for a medium-sized drip system with 8 lateral lines having 160 dripping holes in total (as in 2004). Exchange rate US$1 = NRs 73 in 2004.

Assessment

Acceptance/adoption

Local farmers started to adopt the technology after the 1999 to mid-2001 testing and demonstration period. The technology was promoted by government, community-based, and non-government organisations. About 50 PARDYP-organised farmers accepted and adopted the technology. Among them about 58% accepted the technology with the cost of the kit subsidised whilst 42% adopted it without any subsidy. Fifty-five other households in the watershed accepted the technology as promoted by a local NGO with technical support from PARDYP.

Drivers for adoption

- Testing and demonstrating the technology in a participatory way
- Making the drip sets and spare parts available in local markets
- Providing technical support for establishing and maintaining the sets; local NGOs and lead farmers can provide this.
- Microcredits for poor families to buy drip sets

Constraints to adoption

- Farmers do not have easy access to the drip sets and associated parts
- Capacity building programmes on drip irrigation often target only well-off families and male farmers
- Lack of micro-credit facilities for poor families

Benefits/costs according to land users

The practice delivers quick and tangible benefits so that users usually get a return on the cost of investment after only one crop season.

Benefits compared with costs	short-term	long-term
establishment	positive	very positive
maintenance/recurrent	very positive	very positive

Impacts of the technology

Production and socioeconomic benefits

+ +	Increased farm incomes: extra income (US$ 700/ha) due to early harvest (22 days earlier) of bitter gourd under drip irrigation allowing it to be sold as an off-season vegetable for a higher price
+ + +	Reduced cost and time for irrigation and applying fertiliser (fertigation)

Production and socioeconomic disadvantages

none

Socio-cultural benefits

+ + +	Improved knowledge of SWC/erosion: land users become familiar with new technology, they share experience on drip during gatherings
+ +	Strengthened community institution due to increased number of drip users

Socio-cultural disadvantages

-	Cropping area increased due to the technology; this increased women's workload, but also increased their self-esteem

Ecological benefits

+ + +	Increased soil moisture due to applying water directly to plants' root zones
+ +	Reduced water loss through evaporation, percolation, and distribution
+	Reduced soil loss due to slow and precise delivery of water

Ecological disadvantages

- -	Mono-cropping practised: majority of farmers grow bitter gourd, cauliflower is the second most popular vegetable

Off-site benefit

+ +	Water saving: less water used to irrigate crops making more water available for other uses/crops

Off-site disadvantages

-	Spread of the system could lead to increased upstream water consumption that leaves less water available for downstream users

Concluding statements

Strengths and ➔how to sustain/improve	**Weaknesses** and ➔how to overcome
Drip irrigation saved 60% of water compared to bucket irrigation; dry season (off-season) vegetable production became possible and cropping area increased on areas with limited access to irrigation water ➔ Construction of water harvesting ponds and the use of collected water in drip systems makes for sustainable crop production	Technology is not suitable for sloping land and covers only a small area (using a medium-sized kit) ➔Modifying and levelling slopes and increasing the number of drip kits can overcome this limitation
Plant to plant visits are not required while irrigating, so irrigation, fertigation, and weeding take less time – the technology needs 50% less labour compared to bucket irrigation ➔ Experience sharing and interactions among drip users and non-users, easy access to technology with necessary trainings	The spacing of the drip holes does not match the farmer's needs ➔Make pipes available with at least 50 cm distance between drip holes
Additional household income (~$700/ha) due to early fruiting in case of bitter gourd (comparative study of drip vs. bucket irrigation) ➔Options for other potential high value cash crops should be explored	Spare parts are not available in the local market and farmers have to travel far (to Kathmandu) to get spare parts ➔ Make parts available locally

Key reference(s): ICIMOD (2007) *Good Practices in Watershed Management, Lessons Learned in the Mid Hills of Nepal.* Kathmandu: ICIMOD ■ Prajapati-Merz, B. (2003) *'Drip Irrigation System.'* In PARDYP Annual Report 2003 submitted to ICIMOD, Kathmandu ■ Shrestha, S. (2004) *Adoption of Drip Technology and It's Impact on Gender: a Case Study from Jhikhu Khola Watershed,* a report submitted to PARDYP project, ICIMOD, Kathmandu, Nepal ■ Von Westarp, S. (2002) *Agricultural Intensification, Soil Fertility Dynamics, and Low Cost Drip Irrigation in the Middle Mountains of Nepal,* M.Sc. Thesis. Vancouver: University of British Columbia

Contact person(s): HIMCAT/WOCAT Coordinator, International Centre for Integrated Mountain Development (ICIMOD), GPO Box 3226, Kathmandu, Nepal, himcat@icimod.org

Left: Compost pit covered to protect from rain and direct sunlight (Juerg Merz)
Right: Simple compost pit covered with a plastic sheet and leaf litter (Juerg Merz)

Improved compost preparation

Nepal: सुधारिएको कम्पोष्टमल निर्माण

Improved compost preparation using a range of biomass and waste to produce high value fertiliser

Compost can be prepared from a wide range of organic materials including dead plant material such as crop residues, weeds, forest litter, and kitchen waste. Compost making is an efficient way of converting all kinds of biomass into high value fertiliser that serves as a good alternative to farmyard manure, especially for crop-growing households without livestock. The compost is often mixed with forest soil, ripe compost from the previous batch, or even a small amount of animal dung as a starter for the decomposition process. The mix of materials determines the quality of the final compost as much as the management of the composting process. Nitrogen-rich fresh materials such as legume residues and many types of weeds and shrubs are mixed with carbon-rich forest litter and cereal residues. Small amounts of wood ash, lime, or mineral fertiliser can help increase or balance the overall nutrient content of the compost.

The compost needs to be turned every 30-50 days depending on the mix and the outside temperature. It should be protected from direct sunlight, rainfall and runoff so as to reduce volatilisation and leaching of nutrients. The material must remain moist at all times to avoid slowing down decomposition and hindering the efficiency of the micro and macro-organisms involved in decomposition. Heaping the compost or collecting the material in a pit helps the compost to reach the temperatures needed (70^{0}C) to destroy pests and weeds.

Once the compost is well decomposed and has an earthy smell, it can be applied directly or stored for later application. It can be applied as a crop fertiliser in rows or to individual plants for improving general soil fertility and organic matter content, thus improving the soil structure and its water holding capacity.

The Sustainable Soil Management Programme (SSMP) implements its projects in several midhills districts of Nepal
(dark green: previous working districts;
light green: districts in 2007)

WOCAT database reference: QT NEP7
Location: Nepal midhills
SWC measure: Management
Land use: Annual cropping on rainfed agricultural land
Climate: Humid subtropical
Related approach: Farmer- to-farmer diffusion (QA NEP1); Farmer-led experimentation (QA NEP3); Farmer field school on integrated plant nutrient systems (QA NEP4)
Compiled by: SSMP
Date: January 2007

The Sustainable Soil Management Programme is implemented by Helvetas Nepal and Intercooperation in collaboration with the Government of Nepal and civil society actors. It is financed by the Swiss Agency for Development and Cooperation. The technology was documented using the WOCAT (www.wocat.org) tool.

Classification

Land use problems

Intensifying cultivation practices with either 1) the inadequate application of fertilisers leading to a decline in soil fertility and the mining of soil nutrients or 2) the application of too much fertiliser causing environmental problems through excessive leaching, and losses of fertiliser in surface runoff and consequent eutrophication or nitrification of streams, ponds or groundwater.

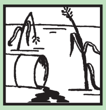
Land use

Annual crops: maize-wheat, potato, mustard, different types of vegetables

Climate

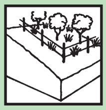
Humid subtropical

Degradation



Chemical degradation: soil fertility decline, soil nutrient mining

SWC measures



Management: compost quality improvement

Technical function/impact

Main:
- increase in soil fertility and productivity
- increase in soil organic matter content
- improvement in physical soil conditions
- increase in soil water holding capacity

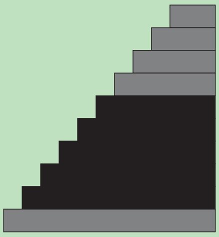
Secondary:

Environment

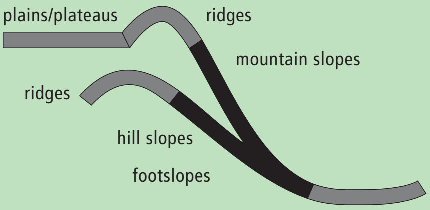
Natural environment

Average annual rainfall (mm)

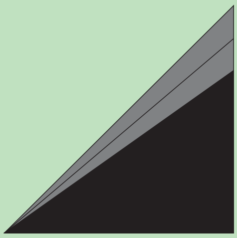
Altitude (masl)



Landform



Slope (%)



Applied Potential

Human environment

Cultivated land per household (ha)

Land use rights: individual, leased (sharecropping between owner and tenant)

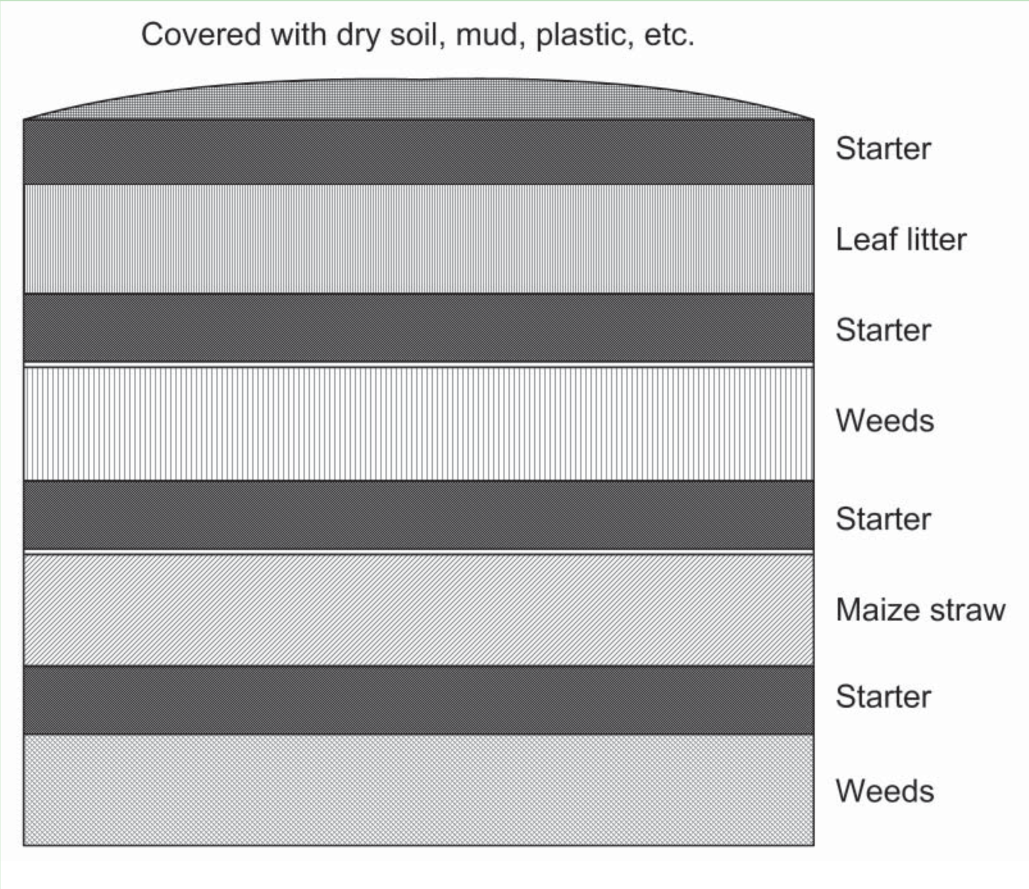
Land ownership: individually owned, titled and not titled

Market orientation: subsistence, commercial, and mixed (subsistence/commercial)

Level of technical knowledge required: low

Number of livestock: poor households usually have some goats and one cow or buffalo, wealthier households often own several cattle, buffaloes, and a pair of oxen for ploughing

Importance of off-farm income: in most farm households, off-farm income plays at least a minor and increasingly a major role. Occasional opportunities for off-farm income present themselves in the form of daily labour wages. Some households' members receive regular salaries, whilst an increasing number of Nepalis are working in India, the Middle East, Malaysia, and elsewhere and sending remittance incomes home.



Technical drawing
Layering of the different materials in a compost pit

Note: This is just an example and need not be followed exactly. The important aspects are:

- the need for a starter such as forest soil or manure
- place weeds in the centre of the pit so that they are fully decomposed
- cover dry materials with moist material and material that only decays slowly with easily decaying material.

The pit can be 1 to 2m in diameter and about 1m deep.
The size depends on the available biomass for composting and the amount of compost required.

Implementation activities, inputs and costs

Establishment activities

1. Dig a 1-2m diameter and 1m deep pit using a spade or shovel
2. Collect crop residues, grass, tree leaves, ash, lime, and animal urine
3. Put a layer of ash at the bottom of the pit followed by tree leaves, grass, crop residues, and a layer of forest soil (as it contains the necessary microorganisms – bacteria, fungi, etc. – and quickens the decomposition process)
4. Add more tree leaves, crop residues, and grass until the pit is full and contains a healthy mixture of dry and fresh/moist materials
5. Cover the compost heap with a fine layer of ash or mud and a cap of grass or straw or plastic sheet

Duration of establishment: 1-2 days

Establishment inputs and costs

Inputs	Cost (US$)[1)]	% met by land user
Labour (1-2 days)	4	100%
TOTAL	**4**	**100%**

[1)] Exchange rate US$ 1 = NRs 67 in January 2007

Maintenance/recurrent activities

1. Dispose of domestic and household wastewater and cattle urine in the pit to keep it moist (but not saturated/soaked) until it is fully decomposed.
2. The compost needs to be turned every 30-50 days depending on the mix and the outside temperature.
3. Depending on the location, it takes about 3-6 months for the compost to be fully decomposed.

Maintenance/recurrent inputs and costs year

Inputs	Cost (US$)[1)]	% met by land user
Labour (~ 1 day)	2	100%
TOTAL	**2**	**100%**

[1)] Exchange rate US$ 1 = NRs 67 in January 2007

Assessment

Acceptance/adoption

About 30% of the participants of SSMP activities related to compost making adopted improved compost production. About 20% of farmers that were not part of the programme but came into contact with this technology, also adopted it. The semi-compost pit (a shallow pit with stone masonry wall around) was not well adopted due to high initial establishment costs.

Drivers for adoption

- Simple technology close to and derived from traditional practices and using locally available materials
- Compatible with traditional practices
- Moderately fast impact is visible (mainly through better physical conditions of the soil)
- Reduced pest incidence in the soil due to well decomposed compost
- No need for livestock
- Inexpensive (except semi-pit method)

Constraints to adoption

- Not suitable for large and commercial scale agriculture (except for nurseries and seed beds)
- Labour intensive

Benefits/costs according to land users

The high cost of mineral fertilisers means that the establishment costs are soon recovered. In the long-term, a major reduction in costs leads to large benefits.

Benefits compared with costs	short-term	long-term
establishment	positive	positive
maintenance/recurrent	positive	positive

Impacts of the technology*

Production and socioeconomic benefits

- +++ Reduced expenses on chemical fertilisers
- +++ Improved soil fertility
- +++ Allows organic crop production

Production and socioeconomic disadvantages

- -- Preparation of compost is labour intensive

Socio-cultural benefits

none

Socio-cultural disadvantages

none

Ecological benefits

- +++ Reduced application of fertilisers

Ecological disadvantages

- \- If forest litter is removed for composting material it impoverishes the forest soil

Off-site benefit

- ++ Reduction of dependence on external inputs
- ++ Reduction of nutrient influx into water bodies

Off-site disadvantages

none

* All changes in technology may have gender and equity implications and potentially affect the members of disadvantaged groups differently. This has not been assessed here but should be considered when recommending technology use.

Concluding statements

Strengths and ➔how to sustain/improve	**Weaknesses** and ➔how to overcome
The use of compost reduced the need for mineral fertiliser thus reducing production costs and outside dependence ➔ Further promote the technology to increase this impact	The preparation of compost is not appropriate for commercial use (except in nurseries)
Compost making does not require any livestock ➔ Its low cost and use of local materials makes it the fertiliser of choice for poor households	Compost requires a large amount of biomass which may otherwise be needed for fuel, fodder, or animal bedding ➔Compost improvement should go hand-in-hand with promoting alternatives for the other requirements
In-situ composting saves labour involved in transporting compost to the fields	

Key reference(s): STSS; SSMP (2001) *Farmyard Manure and Compost Management* (in Nepali). Kathmandu: Soil Testing Services Section, Department of Agriculture and Sustainable Soil Management Programme

Contact person(s): Director, Soil Management Directorate, Department of Agriculture, Harihar Bhawan, Lalitpur, +977 1 5520314 or
Team Leader, Sustainable Soil Management Programme (SSMP), GPO Box 688, Kathmandu/Nepal, +977 1 5543591 ssmp@helvetas.org.np

Left: Farmyard manure heap (Juerg Merz)
Right: Farmyard manure semi-pit (Juerg Merz)

Better quality farmyard manure through improved decomposition

Nepal: उपयुक्त विघटन प्रक्रियाद्वारा राम्रो गुणस्तरको गोठेमल

Collection and proper storage of farmyard manure in heaps or pits

Farmyard manure – a varying mixture of animal manure, urine, bedding material, fodder residues, and other components – is the most common form of organic manure applied in the midhills of Nepal. Farmyard manure has a high proportion of organic material which nurtures soil organisms and is essential in maintaining an active soil life. Only about half of the nutrient content of farmyard manure becomes available for crop growth during the first year after it has been applied to the soil – the rest is channelled through soil biotic processes and the nutrients are released in the following years. The high organic matter content and the active soil life improve or maintain friable soil structures, increase the cation exchange capacity, water holding capacity, and infiltration rate, and reducing the risk of soil pests building up.

Indigenous methods of preparing and using farmyard manure vary widely depending on the ecological zone, access to bedding material from crop or forest land, access to crop residues and fodder, labour availability, and other factors. A prerequisite for the manure having a positive impact on soil fertility is that it is properly decomposed. The application of partially decomposed manure can increase the number of white grubs, red ants and other soil pests.

Decomposition is enhanced and the time it takes to happen is reduced if the manure is kept warm and moist (but not wet) at all times. Heaping the manure up or storing it in a pit helps. Whether it is best to heap up the manure or put it in a pit depends on the local climate. Heaping has the advantage of being less costly, while the pit method reduces runoff and the loss of nutrient rich fluids. Adding nitrogen in the form of urine (N) improves the carbon to nitrogen ratio.

The Sustainable Soil Management Programme (SSMP) implements its projects in several midhills districts of Nepal (dark green: previous working districts; light green: districts in 2007)

WOCAT database reference: QT NEP8
Location: Nepal midhills
SWC measure: Management
Land use: Annual cropping on rainfed agricultural land
Climate: Humid subtropical
Related approach: Farmer-to-farmer diffusion (QA NEP1); Farmer-led experimentation (QA NEP3); Farmer field school on integrated plant nutrient systems (QA NEP4)
Compiled by: SSMP
Date: January 2007

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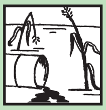
Land use

Annual crops: maize-wheat, potato, mustard, different types of vegetables

Climate

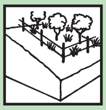
Humid subtropical

Degradation



Chemical degradation: soil fertility decline, soil nutrient mining

SWC measures



Management: heaping or storage in pits

Technical function/impact

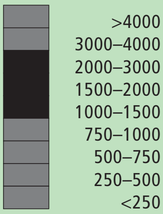
Main:
- increase in soil fertility
- increase in soil productivity
- increase in organic matter

Secondary:
- increased infiltration rate and water holding capacity
- improved soil physical properties

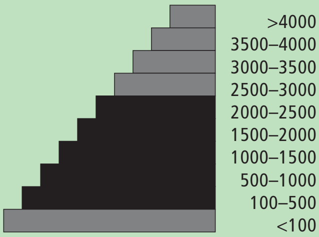
Environment

Natural environment

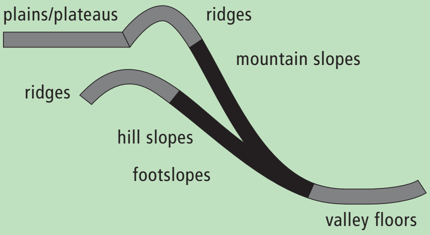
Average annual rainfall (mm)



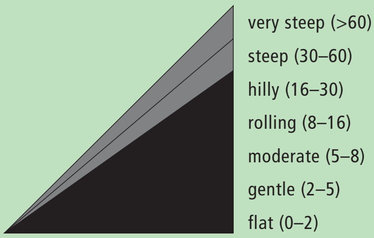
Altitude (masl)



Landform



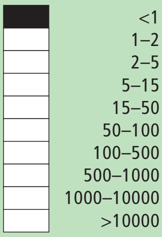
Slope (%)



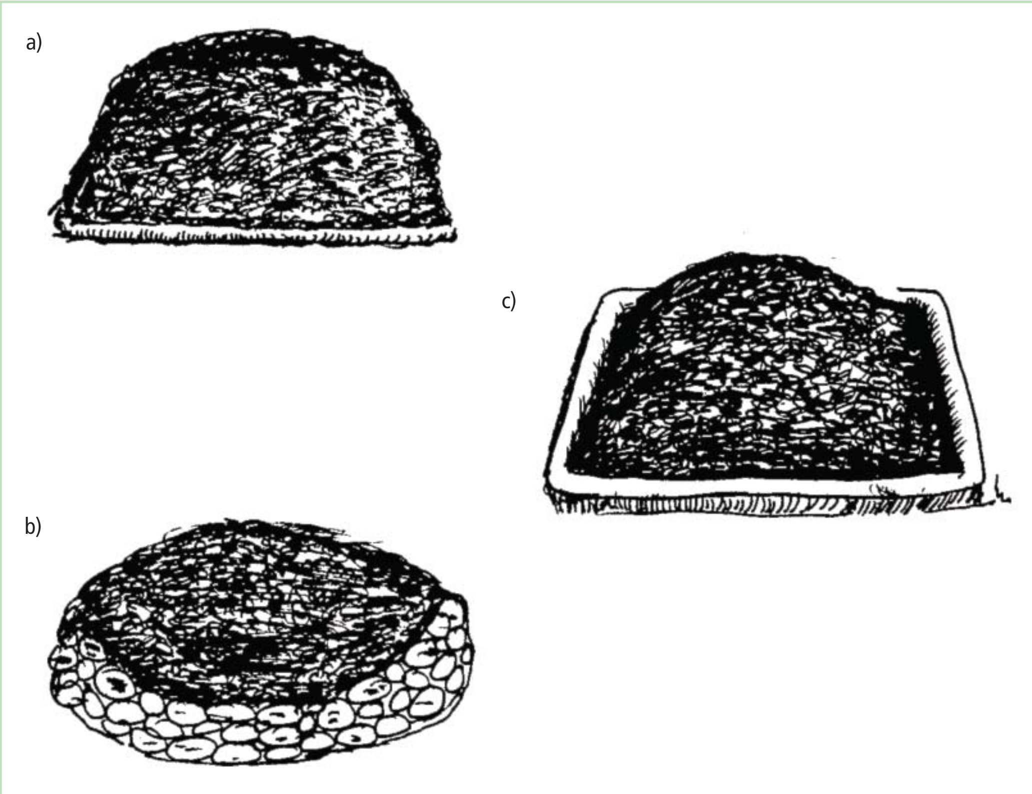
Applied   Potential

Human environment

Cultivated land per household (ha)



Land use rights: individual, leased (sharecropping between owner and tenant)
Land ownership: individually owned, titled and not titled
Market orientation: subsistence, commercial, and mixed (subsistence/commercial)
Level of technical knowledge required: low
Number of livestock: poor households usually have some goats and one cow or buffalo. wealthier households often own several cattle, buffaloes and a pair of oxen for ploughing.
Importance of off-farm income: in most farm households, off-farm income plays at least a minor and increasingly a major role. Occasional opportunities for off-farm income present themselves in the form of daily labour wages. Some households' members receive regular salaries, whilst an increasing number of Nepalis are working in India, the Middle East, Malaysia, and elsewhere and sending remittance incomes home.



Technical drawing

a) Heap method
b) Pit method
c) Semi-pit method

The method should be chosen that is most convenient and provides the most favourable environment for decomposition of the manure. Generally heaps and pits are about 1 to 2m in diameter depending on the amount of manure produced and required.

Implementation activities, inputs and costs

Establishment activities (pit method)[1]

1. Dig a 1m deep and 2m diameter pit using a shovel or spade.
2. Put dung mixed with leaf litter, bedding material and fodder residues in the pit until it is full.
3. Apply urine directly over the manure heap using a plastic pipe or jug.
4. Cover the heap with a fine layer of straw, mud, soil or plastic sheet or any other suitable local materials to protect it from direct sunlight and excessive water.

Duration of establishment: ~ 1 day

Establishment inputs and costs per pit

Inputs	Cost (US$)[2]	% met by land user
Labour (1day)	2	100%
TOTAL	**2**	**100%**

[1] The heap method is cheaper, as no digging is involved [2] Exchange rate as of January 2007, US$1 = NRs 67

Maintenance/recurrent activities

1. About one month after beginning to collect and pile up the material, turn the heap over manually using a spade or shovel.
2. Depending on the location, it takes about 3-4 months to prepare fully decomposed farmyard manure.

Maintenance/recurrent inputs and costs year

Inputs	Cost (US$)[1]	% met by land user
Labour for turning (1 day)	2	100%
TOTAL	**2**	**100%**

[1] Exchange rate as of January 2007, US$1 = NRs 67

Assessment

Acceptance/adoption

The heap and pit methods have been very well accepted and adopted widely among participants in SSMP. The collaborating institutions report that 60-70% of participating farmers have adopted the method. The semi-pit method is not as accepted as the other methods due to its high initial establishment costs.

Drivers for adoption

- Simple technology close to and derived from traditional practices and based on local materials.
- Improvement of the traditional practices
- Moderately fast visible impact (mainly through better physical conditions of the soil).
- Reduced soil pest incidence due to well decomposed farmyard manure)
- Inexpensive (except semi-pit method because of the cost of the stone masonry wall around the pit)

Constraints to adoption

- Expensive initial establishment cost in the case of semi-pit method
- Livestock required (compost is the best alternative for farmers without livestock)

Benefits/costs according to land users

The high costs of mineral fertiliser mean that the establishment costs are recovered quarterly. Over the long-term, the major reduction in costs leads to large benefits.

Benefits compared with costs	short-term	long-term
establishment	positive	positive
maintenance/recurrent	positive	positive

Impacts of the technology*

Production and socioeconomic benefits		Production and socioeconomic disadvantages
+++	Reduced cash expenses on agrochemicals (fertilisers, pesticides) (substituted by labour)	none
+	Increased yields	
+	Reduced incidence of soil pests (white grub, red ant)	

Socio-cultural benefits		Socio-cultural disadvantages
++	Cleaner environment around houses if manure heap or pit is well maintained	none

Ecological benefits		Ecological disadvantages
+++	Reduced application of mineral fertilisers	none

Off-site benefit		Off-site disadvantages
++	Reduced dependence on outside inputs	none
++	Reduced influx of nutrients into water bodies	

* All changes in technology may have gender and equity implications and potentially affect the members of disadvantaged groups differently. This has not been assessed here but should be considered when recommending technology use.

Concluding statements

Strengths and ➔how to sustain/improve	**Weaknesses** and ➔how to overcome
The use of improved and well-decomposed farmyard manure reduced the need for mineral fertiliser and pesticides thereby reducing production costs, cash expenditure, and outside dependency ➔ Further promote the technology to increase this impact	The initial establishment costs for building a semi-pit may hamper adoption ➔Promote alternative methods of building a semi-pit without using cement and using local resources
The use of fully decomposed farmyard manure reduces pest incidence, especially attacks of red ants and white grubs	

Key reference(s): STSS; SSMP (2001) *Farmyard Manure and Compost Management* (in Nepali) Kathmandu: Soil Testing Services Section, Department of Agriculture and Sustainable Soil Management Programme

Contact person(s): Director, Soil Management Directorate, Department of Agriculture, Harihar Bhawan, Lalitpur, +977 1 5520314 or
Team Leader, Sustainable Soil Management Programme (SSMP), GPO Box 688, Kathmandu/Nepal, +977 1 5543591 ssmp@helvetas.org.np

Left: Farmyard manure covered by a creeper and tin sheet (left) (Juerg Merz)
Right: Covered farmyard manure in a field (Juerg Merz)

Improved farmyard manure through sunlight, rain and runoff protection

Nepal: घाम, भलपानी र बलेनीबाट बचाई निर्माण गरिएको राम्रो गुणस्तरको गोठेमल

Improving farmyard manure by protecting it from direct sunlight, rainfall, and runoff to reduce volatilisation and leaching

Farmyard manure is the most common form of organic fertiliser applied to crops in the midhills of Nepal. Farmyard manure has a high proportion of organic material which nurtures soil organisms and is essential for maintaining an active soil life. Typically, only about half of the nutrient content of farmyard manure becomes available for crop growth during the first year after it is applied to the soil. The rest of the nutrients are channelled through soil biotic processes and are released in the following years. The high organic matter content and the more active soil life improve or maintain a friable soil structure, increase the cation exchange capacity, the water holding capacity, and the infiltration rate, and reducing the risk of soil pests.

Indigenous methods of preparing and using farmyard manure vary depending on the ecological zone, access to bedding material from crop or forest land and to crop residues and fodder, the availability of labour, and other factors. Traditionally, Nepali farmers take the manure out of their sheds to dry it for 2-3 days and then carry it to the field where it is left in small heaps for a number of days before being spread and incorporated into the soil.

Farmers rate the quality of manure according to which livestock species it comes from. These ratings have been confirmed by nutrient analysis as cattle manure (NPK%: 0.6, 0.13, 0.66) is considered to be better than buffalo manure (0.33, 0.25, 0.10), and horse manure; while pig (0.5, 0.18, 0.42), goat (0.6, 0.13, 0.99), and sheep manure (0.6, 0.13, 0.99) are considered better than cattle manure. Chicken manure (1.46, 0.51, 0.51) is considered the best of all.

It has however been shown that considerable nutrient losses occur if the manure is inappropriately handled or stored. Drying of the manure leads to loss of nutrients through volatilisation, and rainfall and runoff leads to leaching or washing out of nutrients. In addition, the common disposal of urine – the part of the excreta with the highest nutrient concentration – further reduces the level of nutrients in manure.

To reduce nutrient losses farmyard manure needs to be protected from direct sunlight; protected from rainfall or run-on; and protected from runoff. This can be achieved in a variety of ways using a variety of inputs. It is most important to protect the manure during storage and just before it is applied in the field to make the best use of this valuable local resource.

The Sustainable Soil Management Programme (SSMP) implements its projects in several midhills districts of Nepal
(dark green: previous working districts;
light green: districts in 2007)

WOCAT database reference: QT NEP9
Location: Nepal midhills
SWC measure: Management
Land use: Annual cropping on rainfed agricultural land
Climate: Humid subtropical
Related approach: Farmer-to-farmer diffusion (QA NEP1); Farmer-led experimentation (QA NEP3); Farmer field school on integrated plant nutrient systems (QA NEP4)
Compiled by: SSMP
Date: January 2007

The Sustainable Soil Management Programme is implemented by Helvetas Nepal and Intercooperation in collaboration with the Government of Nepal and civil society actors. It is financed by the Swiss Agency for Development and Cooperation. The technology was documented using the WOCAT (www.wocat.org) tool.

Classification

Land use problems

Intensifying cultivation practices with either 1) inadequate application of fertilisers leading to a decline in soil fertility and the mining of soil nutrients or 2) application of too much fertiliser causing environmental problems through excessive leaching, and losses of fertiliser in surface runoff and consequent eutrophication or nitrification of streams, ponds or groundwater

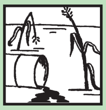
Land use

Annual crops: maize-wheat, potato, mustard, different types of vegetables

Climate

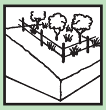
Humid subtropical

Degradation



Chemical degradation: soil fertility decline, soil nutrient mining

SWC measures



Management: protect farmyard manure; change application

Technical function/impact

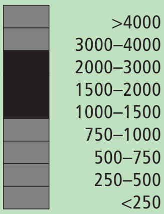
Main:
- increase in soil fertility
- increase in soil productivity
- increase in organic matter

Secondary:
- increased infiltration rate and water holding capacity
- improved soil physical properties (friability, easier soil preparation)

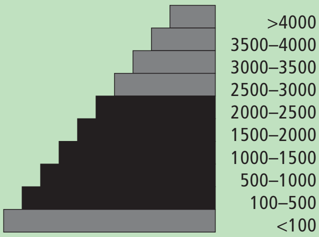
Environment

Natural environment

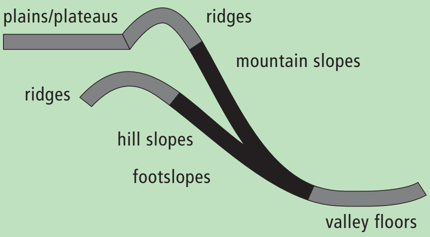
Average annual rainfall (mm)



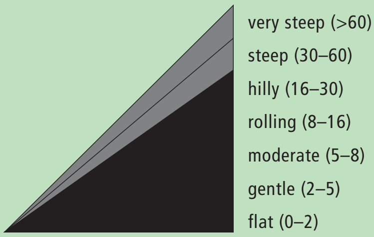
Altitude (masl)



Landform



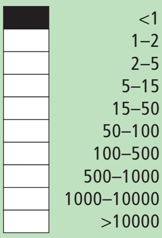
Slope (%)



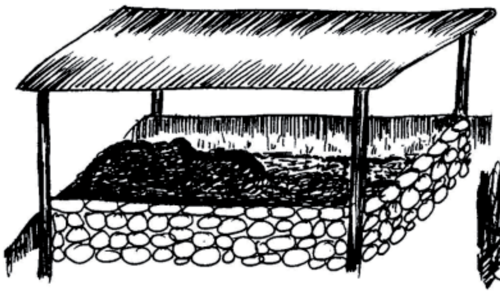
Applied Potential

Human environment

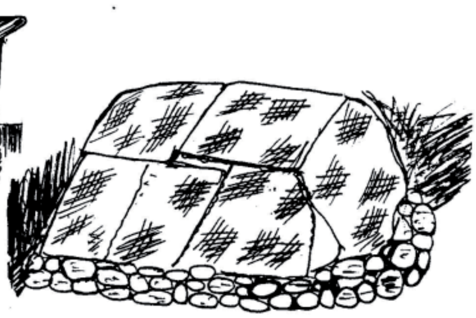
Cultivated land per household (ha)



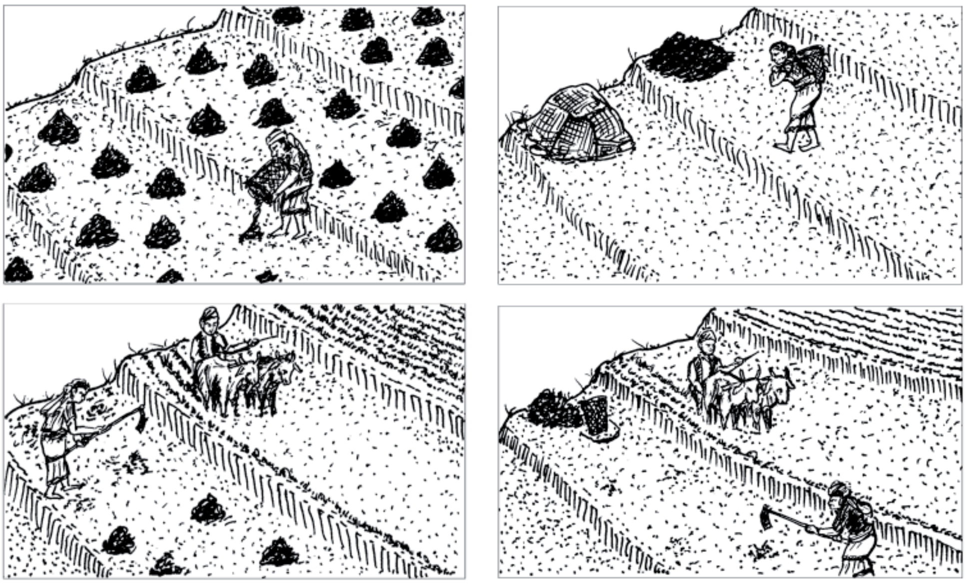
Land use rights: individual, leased (sharecropping between owner and tenant)
Land ownership: individually owned, titled and not titled
Market orientation: subsistence, commercial, and mixed (subsistence/commercial)
Level of technical knowledge required: low
Number of livestock: poor households usually have some goats and one cow or a buffalo, wealthier households often own several cattle, buffaloes and a pair of oxen for ploughing.
Importance of off-farm income: in most farm households, off-farm income plays at least a minor and increasingly a major role. Occasional opportunities for off-farm income present themselves in the form of daily labour wages. Some households' members receive regular salaries, whilst an increasing number of Nepalis are working in India, the Middle East, Malaysia, and elsewhere and sending remittance incomes home.



Cover made of tin sheet



Cover made of plastic sheets or gunny bags (jute sacks)



Technical drawing

a) Covering the farmyard manure with a roof made of tin sheet or plastic sheets. Cheaper alternatives are:
- a thatched roof
- shading with creepers like cucurbits
- planting broadleaf mustard on the heap
- applying a covering of crop residues or forest material

b) Farmyard manure is traditionally carried to the fields in doko baskets and left there in unprotected heaps to be incorporated often weeks and sometimes several months later (top and bottom left). It is much better to incorporate it on the day of transport as the longer it is left out on the fields in heaps the greater are the nutrient losses from the heaps (bottom right). Alternatively it can be stored in a corner of the field covered with plastic sheets, crop residues, or in some other way (top right).

Implementation activities, inputs and costs

Establishment activities

1. Cover the farmyard manure heap or pit with any available material (crop residues, forest material, plastic sheet, thatched roof, zinc sheet, etc.)

Duration of establishment: < 1 day

Establishment inputs and costs

Inputs	Cost (US$)[1]	% met by land user
Depending on materials	0-25	100%
Labour	2	100%
TOTAL	**0-27**	**100%**

[1] Exchange rate as of January 2007, US$1 = NRs 67

Maintenance/recurrent activities

1. Pour household wastewater onto the heap or pit to keep the farmyard manure moist (but not saturated). This enhances decomposition.

Maintenance/recurrent inputs and costs per ha per year

Inputs	Cost (US$)	% met by land user
Labour	negligible	100%
TOTAL	**negligible**	**100%**

Assessment

Acceptance/adoption

This technology found a very high rate of acceptance despite the extra labour involved. An independent assessment found that 95% of the farmers participating in SSMP's farmyard improvement activities were found to be protecting their farmyard manure from direct sunlight, rainfall and runoff and had changed their way of applying the manure to the field by straight-away incorporating it into the soil. About 70% of non-participant farmers who had come into contact with the technologies had also adopted them. These results are supported in the annual reports from SSMP's collaborating institutions.

Drivers for adoption

- A simple technology allied to and derived from traditional practices
- Compatible with traditional practices
- Moderately fast impact visibility (mainly through better physical conditions of the soil)
- Inexpensive

Constraints to adoption

- Labour requirement is shifting in time, (i.e. more work is needed during the ploughing than during the everyday transport of manure)
- Livestock is required to produce the manure

Benefits/costs according to land users

Large short- and long-term benefits due to need to use less of the costly mineral fertilisers. The only extra 'cost' is the extra labour needed.

Benefits compared with costs	short-term	long-term
establishment	positive	positive
maintenance/recurrent	positive	positive

Impacts of the technology*

Production and socioeconomic benefits

+++	Reduced expenditure on mineral fertilisers
++	Increased yield

Production and socioeconomic disadvantages

none

Socio-cultural benefits

none

Socio-cultural disadvantages

none

Ecological benefits

+++	Improved physical soil characteristics

Ecological disadvantages

none

Off-site benefit

++	Reduction of outside dependence
++	Reduction of nutrient influx into water bodies

Off-site disadvantages

none

* All changes in technology may have gender and equity implications and potentially affect the members of disadvantaged groups differently. This has not been assessed here but should be considered when recommending technology use.

Concluding statements

Strengths and ➔**how to sustain/improve**

The use of improved farmyard manure reduced the need for mineral fertiliser thereby reducing production costs and outside dependency ➔ Further promotion of the technology will increase this impact

A simple technology affordable by poor farmers in remote areas far from a roadhead

The increased use of organic fertiliser improves the physical characteristics of soil making ploughing easier and increasing water holding capacity of the soil

Weaknesses and ➔**how to overcome**

Cost of a permanent roof for the manure heap may hinder adoption of the technology ➔Promote simple alternatives to high cost roofs such as straw cover, cover with broad leaf mustard, thatch, and waste plastic

Key reference(s): STSS; SSMP (2001) *Farmyard Manure and Compost Management* (in Nepali) Kathmandu: Soil Testing Services Section, Department of Agriculture and Sustainable Soil Management Programme

Contact person(s): Director, Soil Management Directorate, Department of Agriculture, Harihar Bhawan, Lalitpur, +977 1 5520314 or
Team Leader, Sustainable Soil Management Programme (SSMP), GPO Box 688, Kathmandu/Nepal, +977 1 5543591 ssmp@helvetas.org.np

Left: Irrigation of traditional paddy rice terraces; the water is drained from one terrace to the next through narrow openings. Note the pile of manure on the upper terrace ready for applying to the field (Hanspeter Liniger)
Right: Maintenance: farmer scraping/slicing the terrace riser; the material is then spread on the fields, improving soil fertility (Hanspeter Liniger)

Traditional irrigated rice terraces

Nepal: टारी खेत

Level bench terraces with risers protected by fodder grasses, used for the irrigated production of rice, potatoes and wheat

The level bench terrace is a traditional technology that makes irrigated crop production possible on steep, erosion-prone slopes. Most such terraces in Nepal were constructed by hand many generations ago; but some new land – mostly already under rainfed cultivation on forward sloping terraces – is still being converted into irrigated terraces. The initial costs for building the terraces are very high and there are high annual maintenance costs. The climate is humid subtropical, the slopes are steep (30-60%), and the soils generally have a sandy loam texture. Terraces are cropped by farmers who mostly have less than 0.5 ha of land each. Two to three annual crops are grown, with paddy rice during the monsoon followed by potatoes and/or wheat.

Terrace beds are usually 2-6m wide and are made as wide as possible to save labour without increasing the danger of slips and landslides. The terraces were originally surveyed by eye, but now a water-tube level is used to survey new terraces. Risers are 0.8-1.5m high with a small lip (20-25 cm). The slope of the riser varies from 80 to 160%, depending on the initial gradient of the hill. Stones are incorporated in the risers, if available, and grass species such as Bermuda grass *(Cynodon dactylon)* and Napier grass *(Pennisetum purpureum)* may be planted to help stabilise the terrace edges and for use as cattle fodder. The risers are compacted (with hoes) to improve ponding conditions for paddy rice. Twice a year the risers are scraped with a special tool: whilst preparing to plant paddy rice the lower parts of risers are sliced, with the upper part left protected with grasses against the monsoon rains; and at the time of planting wheat the whole riser (including the lip) is scraped and spread as green manure on the terrace.

Terraces are flooded with water for paddy rice cultivation, whilst smaller amounts of water are diverted into the fields for other crops. Excess water is drained to lower terraces through openings made in the lip filled with rice straw to stop too much sediment being washed down. The depth of water for rice – when flooded completely – is normally between 10 and 15 cm. Fertility is maintained by adding farmyard manure, by spreading the scraped soil from risers, and also from the sediment carried in the irrigation water. Nowadays, mineral fertilisers are also applied.

WOCAT database reference: QT NEP10
Location: Sankhu Bhulbu, Manmata subwatershed, Kathmandu district
Technology area: 1 km^2
SWC measure: Structural, vegetative and agronomic
Land use: Cropland
Climate: Humid subtropical
Related approach: Not documented (traditional technology)
Compiled by: Ramanand Bhattarai, District Soil Conservation Office, Lalitpur, Nepal
Date: November 2003, updated August 2004

General comments: Irrigated bench terraces are a very common traditional technology, widespread in Nepal on footslopes and across the mid hills of the Himalayas. There are close similarities with the paddy rice terraces of South East Asia in the Philippines, Indonesia, and China.

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

Classification

Land use problems
- steep slopes, not suitable for agriculture in their original state (better for forestry, agroforestry, horticulture, and fruit trees)
- small and scattered plots of land
- land users find chemical fertilisers and water expensive
- there is water scarcity from September to May and too much rain in the monsoon period (June to August) with the danger of erosion and collapse of the terraces

Land use

Annual crops: rice, potatoes, wheat

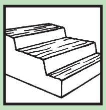
Climate

Humid subtropical

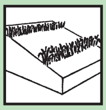
Degradation

Water erosion: gullying, loss of topsoil and mass movement

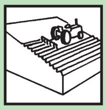
SWC measures



Structural: level bench terraces



Vegetative: fodder grass on risers



Agronomic: green/farmyard manure, inorganic fertilisers

Technical function/impact

Main:
- control of dispersed and concentrated runoff
- reduction of slope angle and length
- increase and maintenance of water stored in soil
- increases soil fertility

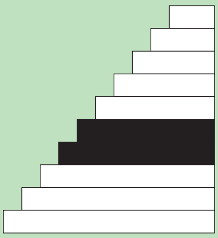
Secondary:
- water harvesting
- water spreading
- improves ground cover

Environment

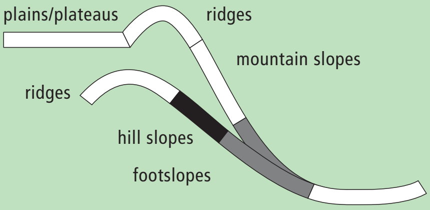
Natural environment

Average annual rainfall (mm)

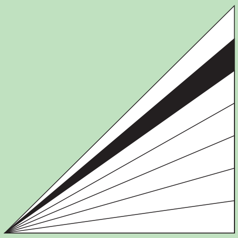
Altitude (masl)



Landform

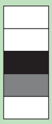


Slope (%)



Applied (large extent) Applied (medium extent)

Soil depth (cm)



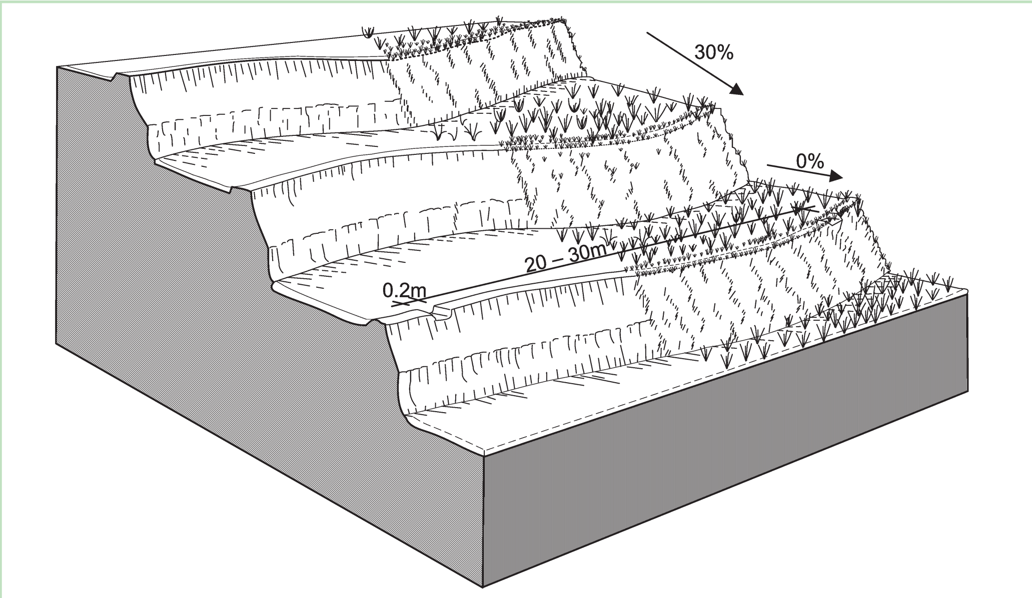
NB: Soil properties before SWC

Growing season: monsoon from June to August, but irrigation extends the growing period to around 330 days (allowing 2-3 crops per year)
Soil fertility: medium
Soil texture: mainly medium (loam), partly coarse (sandy loam)
Surface stoniness: no loose stones
Topsoil organic matter: medium (1-3%)
Soil drainage: good because of the geology and soil texture (loam)
Soil erodibility: mainly high, partly medium

Human environment

Cropland per household (ha)

Land use rights: leased (90% of farmers), individual (10%)
Land ownership: individual, not titled
Market orientation: mixed: subsistence (rice/wheat) and commercial (potatoes)
Level of technical knowledge required: field staff/extension worker: high, land user: high
Number of livestock: not relevant
Importance of off-farm income: 10-50% of all income: hired labour (on other farmers' fields) or as porters



Technical drawing
Layout of irrigated terraces
Openings in the lips drain excess water, grass cover stabilises lips and risers (right).
After harvesting of rice, the grass is scraped off the lower part of the risers (left) and spread on the terrace beds

Implementation activities, inputs and costs

Establishment activities

1. Construct bunds (risers) with soil from upper and lower sides (soil transported in jute bags)
2. Level terrace beds (soil moved from upper to lower part of terraces)
3. Make lips on edges of terraces
4. Compact risers
5. Construct irrigation canal
6. Make openings in lips for drainage of excess water
7. Test-irrigate terrace for accurate levelling
8. Plant grasses including Bermuda grass *(Cynodon dactylon)*
9. After 2-3 years, some narrow terraces may be merged to form single, wider terraces

All activities are done by hand, with 1-6 done before and 7-8 during the monsoon

Duration of establishment phase: not specified

Establishment inputs and costs per ha

Inputs	Costs (US$)[1)]	% met by land user
See remarks below		

Maintenance/recurrent activities

1. Harvest potato/wheat (January-March)
2. Transport cattle manure in a doko (basket carried on the back) to the field and leave it in heaps (March)
3. Spread the cattle manure (normally April)
4. Prepare land (plough/break compacted soil) for rice (April)
5. Flood the paddy fields (June/July), repeated 3-4 times during cultivation
6. Slice/scrape grass and soil on lower part of risers and spread on terraces (when flooded in June/July)
7. Plant rice and apply mineral fertiliser (June/July)
8. Harvest rice (October)
9. Apply manure (cattle manure) after rice harvest (October)
10. Slice/scrape grass and soil from whole of risers and spread on terraces (October/November)
11. Repair small collapses/slumps in risers (Oct/Nov)
12. Prepare land (November)
13. Plant potatoes and wheat (November)
14. Apply of mineral fertiliser (November/December)
15. Irrigate (November - repeated several times during cultivation)

All activities are done by hand except land preparation, which is sometimes done with small tractors or power tillers

Maintenance/recurrent inputs and costs per ha per year (2003)

Inputs	Cost (US$)[1)]	% met by land user
Labour (125 person days)	350	100%
Equipment		
- Tools: hoe, spade, baskets - (doko)	5	100%
Agricultural		
- Fertiliser (650 kg)	185	100%
- Compost/manure (30 tonnes incl. transport)	300	100%
TOTAL	**840**	**100%**

[1)] Exchange rate US$1 = NRs 77 in 2003

Remarks: Current establishment costs are very difficult to determine since the majority of the traditional terraces were established a long time ago. Costs depend closely on the present state of the land (forward sloping terraces or uncultivated) and the need for irrigation canals. Farmers say that construction now could cost up to US$ 10,000 per ha if carried out by hand at full labour cost. The cost given for maintaining the terraces (approx. US$ 840 per ha) includes all associated annual crop production costs. In this case study, 100% of construction costs were borne by the land users.

Assessment

Acceptance/adoption

- All the land users in the case study area who applied the technology did so without any outside incentives. In a nearby area, 50% of costs were met by the Bagmati Integrated Watershed Management Programme when converting existing rainfed forward-sloping terraces into level terraces which can be irrigated
- Maintenance has been continuously good over many generations
- Main motivation: irrigation guarantees high returns from small areas

Benefits/costs according to land users

Benefits compared with costs	short-term	long-term
establishment	very negative	positive
maintenance/recurrent	positive	very positive

Impacts of the technology*

Production and socioeconomic benefits

+++ Increased crop yield
+++ Increased farm income
+++ Increased livestock fodder
++ Increased quantity and quality of fodder

Production and socioeconomic disadvantages

- - - Labour constraints as high labour inputs are needed
- - More inputs required for better production in the initial stages
- - Loss of land due to terrace risers

Socio-cultural benefits

+++ Improved knowledge of SWC/erosion
++ Strengthened community institution

Socio-cultural disadvantages

- Socio-cultural conflicts may arise when agreed and scheduled water extraction amounts are exceeded
- As part of a complex farming system, the technology is vulnerable to changes in norms and traditions (attraction influence of the nearby city for employment takes labour away)

Ecological benefits

+++ Increased soil moisture
+++ More efficient drainage of excess water
+++ Increased soil fertility
+++ Reduced soil loss
++ Enhanced biodiversity
++ Improved soil cover

Ecological disadvantages

- Crabs in irrigation water make holes in the terrace risers, which in turn can cause pipe erosion and riser collapse

Off-site benefit

+++ Reduced downstream flooding
+++ Reduced downstream siltation
+++ Increased groundwater recharge
+++ Increased soil moisture and nutrients downstream
++ Reduced river pollution

Off-site disadvantages

- - Reduced river flows during dry season as river water is used upstream for terrace irrigation
- Poor maintenance of topmost terraces may cause landslides

In this case: impacts of traditional paddy rice terraces in comparison to forward-sloping rainfed terraces

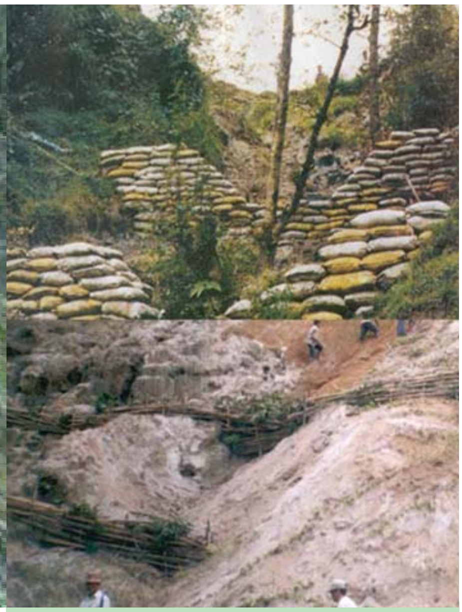
* All changes in technology may have gender and equity implications and potentially affect the members of disadvantaged groups differently. This has not been assessed here but should be considered when recommending technology use.

Concluding statements

Strengths and →how to sustain/improve	**Weaknesses** and →how to overcome
Income and production increased →Proper management of the terraces (including all maintenance activities)	Decreased grass production (grazing area reduced) →Promote planting of high value grass species on risers (such as Bermuda grass)
Easier to cultivate flat terraces/less labour required (after establishment of terraces)	The farmers believe that the terraces are too narrow (for efficient use of tractors); they would like to have wider terraces →Investigate possibilities of constructing wider paddy rice terraces on steep slopes, which, according to present experience, is not possible
Work sharing: traditional terraces are part of a long tradition of work sharing within the community with no external labour needed →Prevent loss of well established traditions and norms	High labour costs for establishment
Technology is easy to understand/apply	
The irrigation element of this technology fosters social bonds within the community →Prevent loss of well established norms and traditions	
Increased opportunities for irrigation facilities: farmers without level terraces are not allowed (by the irrigation committee at village level) or do not claim irrigation water	

Key reference(s): There is considerable literature on the construction and maintenance of irrigated terraces in general, but no references that refer directly to traditional paddy rice terraces in Nepal

Contact person(s): HIMCAT/WOCAT Coordinator, International Centre for Integrated Mountain Development (ICIMOD), GPO Box 3226, Kathmandu, Nepal, himcat@icimod.org



Left: case study area three years after treatment, left side of picture, and showing untreated area affected by steam bank erosion and landslips on the right (Hanspeter Liniger)
Right: Check dams made from cement bags filled with a mixture of sand, earth, cement; and brick chips at Indrayani, Gagalphedi, Kathmandu District (Top: P Mathema); woven bamboo fences positioned in gullies near Bajrayogrini Temple, Kathmandu District (Bottom: I.B. Malla). Both these sites are similar to the case study area.

Landslip and stream bank stabilisation

Nepal: बाँसको भाटा/मान्द्रा बाँधी

Integration of vegetative and structural measures for landslip, stream bank and gully stabilisation on hillsides

A combination of measures were implemented by a group of neighbouring families in the middle hills of Nepal to mitigate the problems caused by landslips, gully formation, and stream bank erosion problems in a local area. These processes were affecting the stability of adjacent agricultural land and causing problems downstream. Small-scale farming is dominant in the area surrounding the treated land – which belongs to the government but is used by these families.

This pilot technological package is proving suitable in Nepal for steep/very steep slopes under humid subtropical climates within the altitudinal range of 1,000–1,500m. This type of intervention, combined with the active involvement of stakeholders (who contributed three-quarters of the costs), was introduced to Nepal under a watershed management programme co-funded by the European Commission (see 'Integrated watershed management QA NEP11').

Initially, contour ditches were built with bunds on the lower side. Then cement bags filled with cement, brick chips, sand, and/or earth, were built up in the gullies and along the stream banks to prevent further deepening of the channels. Wattle fences made from woven bamboo were also put in the gullies to check further erosion. The structures were complemented by vegetative measures with planting of Nepalese alder *(Alnus nepalensis)*, bamboo *(Dendrocalamus sp.)*, cardamom *(Elettaria cardamomum)*, and broom grass *(Thyosonaelana maxima)*. These species establish quickly on degraded sites and also control erosion, stabilise land, and serve as cash crops, and for fodder, fuelwood and timber. Alder (locally called utis) is a nitrogen-fixing multipurpose tree which helps restore soil fertility. The average annual gross production value of the land after the technology was applied increased by about US$ 500/ha.

These plants can provide farmers with economic benefits after only two years. The vegetative resources needed are locally available and cheap and local farmers know how to propagate them; the maintenance costs are negligible. Once established, stabilised and revegetated sites provide improved environments for birds and insects – thus favouring biodiversity – and help protect natural springs. In this case study, the economic returns from the cash crops mainly went to one family, other families extract common products (fodder, litter, timber) for domestic use. The location is regularly used as a demonstration site for farmers and soil and water conservation (SWC) specialists.

WOCAT database reference: QT NEP11
Location: Sakhintar, Kathmandu/Bagmati watershed, Kathmandu district
Technology area: 0.14 km^2
SWC measure: Structural and vegetative
Land use: Wasteland (before) agrosilvopastoral (after)
Climate: Humid subtropical
Related approach: Integrated watershed management, QA NEP11
Compiled by: Dileep K. Karna, Department of Soil Conservation and Watershed Management, District Conservation Office, Kathmandu, Nepal
Date: November 2003
General comments: This promising technology comprises a set of vegetative and structural measures for stabilisation of land where streams are cutting back into fields, or subsurface runoff is causing landslips. Income is generated from various plants. The technology focuses on a problem common to steep land in the tropics and sub-tropics and could be widely applicable both in Nepal and elsewhere.

The technology was documented using the WOCAT (www.wocat.org) tool.
ICIMOD
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Swiss Agency for Development and Cooperation SDC
WOCAT

Classification

Land use problems

- Concentrated runoff from upstream agricultural areas
- Landslides, gullies, and stream bank erosion
- Gullies back-cutting into fertile agricultural land and threatening irrigation canals and homesteads

Land use | **Climate** | **Degradation** | **SWC measures**

Wasteland: degraded shrub land (before) | Agro-silvopatoralism (after) | Humid subtropical | Water erosion: gullying, mass movement, river bank erosion | Chemical: fertility decline | Structural: ditches/bunds, cement bags, wattle fences | Vegetative: tree/shrub cover, grasses (dispersed/ aligned

Technical function/impact

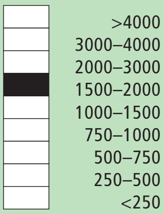
Main:
- impedes/retards concentrated runoff
- improves ground cover
- stabilisation of soil
- reduction of slope angle
- reduction of slope length

Secondary:
- drains/diverts concentrated runoff
- increases infiltration (due to improved groundcover)

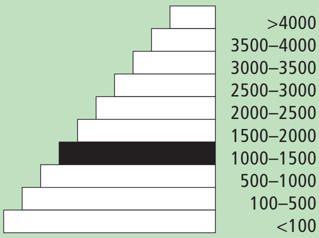
Environment

Natural environment

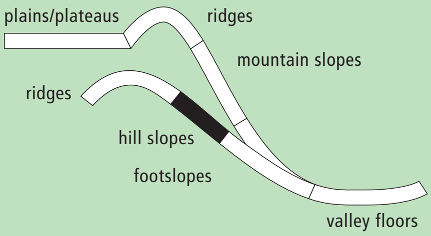
Average annual rainfall (mm)



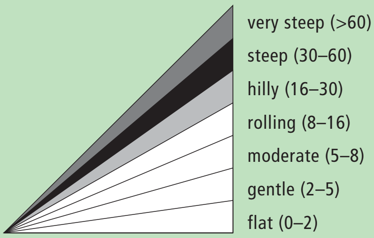
Altitude (masl)



Landform

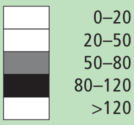


Slope (%)



Applied (large extent) Applied (medium extent) Applied (little extent)

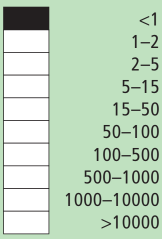
Soil depth (cm)



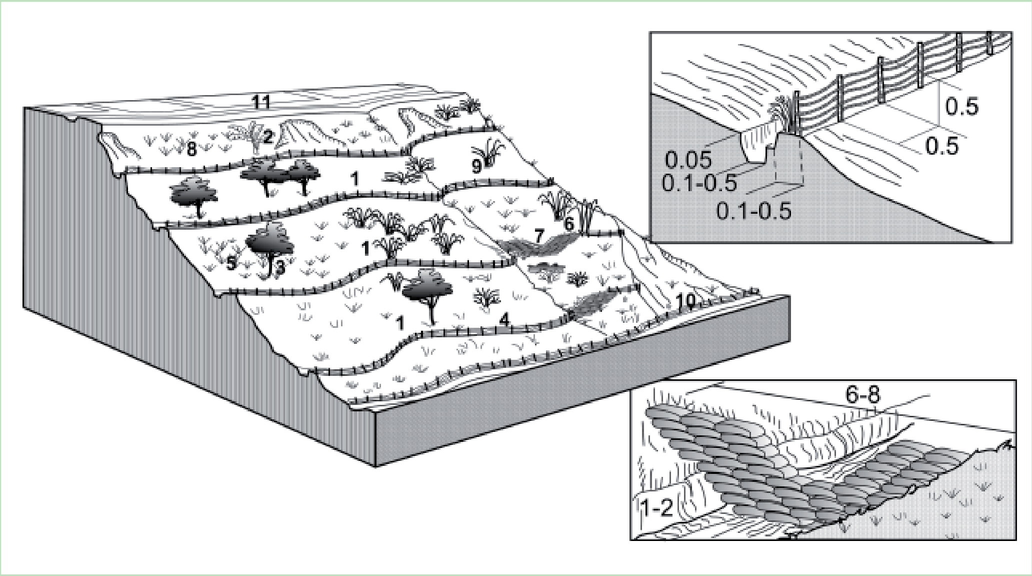
Growing season: 180 days (June to November); crops are grown the whole year round on surrounding irrigated areas
Soil fertility: mostly high, partly medium
Soil texture: mostly medium (loam), partly coarse (sandy)
Surface stoniness: no loose stone
Topsoil organic matter: medium((1-3%)
Soil drainage: medium
Soil erodibility: high

Human environment

Mixed land per household (ha)



Land use rights: open access
Land ownership: state
Market orientation: subsistence and mixed (subsistence and commercial)
Level of technical knowledge required: field staff/extension worker: high during establishment period, low to moderate during maintenance; land user: high for establishment, moderate to high during maintenance
Importance of off-farm income: 10-50% of all income: occasionally teaching at farmers' schools; selling non-timber forest products in local market; some people work in markets/shops/on construction, sites, and similar



Technical drawing
Land slip and stream bank protection: an overview of the multiple and integrated vegetative and structural measures: cut-off drain

1. landslip area
2. banana trees
3. alder trees
4. bamboo wattle fences
5. cardamom
6. planting bamboo
7. cement bag check dams
8. broom grass
9. cutting bamboo
10. stream bank
11. agricultural fields in a flat area

Insert 1: Bamboo wattle fence combined with retention ditch and grassed bund to stabilise steep slopes and gullies.

Insert 2: Old cement bags filled to form checks in gullies

Implementation activities, inputs and costs

Establishment activities

1. Construction of contour bunds and ditches (January–April)
2. Stabilisation of slopes using bamboo wattle fences,and gullies using the check dams
3. Gully stabilisation as walls of cement bags are placed across the gullies and along stream banks (June)
4. Preparation of the site for planting (June)
5. Planting of alder *(Alnus nepalensis,)*, cardamom *(Elettaria cardamomum)*, bamboo *(Dendrocalamus sp.)* and broom grass *(Thyosonaelana maxima)* (July-August)
6. Watering of new plants using buckets (March-May, 1st year)
7. Application of farmyard manure at time of planting, and every December
8. Weeding (January)
9. Earthing up new plants with soil (January)

All activities are carried out manually using local and traditional tools: A-frame, digging axe, hoe, pipe, water pump, baskets, shovel, and hammer

Duration of establishment: 1 year

Establishment inputs and costs per ha

Inputs	Cost (US$)	% met by land user
Labour (1,560 person days)	2,115	75%
Equipment		
- Tools	55	100%
- Empty cement bags (600)	10	0%
Materials		
- Cement bags (30) filled with earth/other material (50 kg each)	125	0%
- Bamboo	0	
Agricultural		
- Seeds (alder: 50g)	0	
- Seedlings (400 large cardamom slips)	5	0%
- Alder: saplings (2,500/ha)	40	100%
- Bamboo cuttings (600)	565	50%
- Manure (1 t/ha)	10	100%
TOTAL	**2,925**	**68%**

Maintenance/recurrent activities

1. Apply farmyard manure (January)
2. Weed (January)
3. Prepare land for further planting of large cardamom and broom grass (March-April)
4. Thin cardamom, bamboo, alder, broom grass with a knife: (May, June)
5. Replant cardamom, broom grass, bamboo that did not establish (June, July)
6. Earth up (August–September and January)
7. Prune alders (December, January)

All activities done annually and by manual labour needing no additional tools (see establishment)

Maintenance/recurrent inputs and costs per ha per year

Inputs	Cost (US$)	% met by land user
Labour (40 person days)	55	100%
Equipment		
- Tools	10	100%
Agricultural		
- Plant material (various)	0	
- Manure (500 kg)	5	100%
TOTAL	**70**	**100%**

Remarks: Labour costs: information based on oral information estimated by a farmer, exchange rate: US$1 = NRs 77 in 2003

Assessment

Acceptance/adoption

The technology was piloted in the case study area. In the meantime, other farmers have taken it up in other areas.

- 18 families (47%) took up the technology with the incentives of partly paid labour and free seedlings, bamboo culms, and cement bags.
- 20 relatively well-off families (53%) spontaneously adopted the technology because of its economic benefits on marginal land; this is a growing trend
- The land users have adequately maintained what has been implemented

Benefits/costs according to land users

Benefits compared with costs	short-term	long-term
establishment	negative	very positive
maintenance/recurrent	positive	very positive

Impacts of the technology*

Production and socioeconomic benefits

+++	Increased fodder production and quality of fodder for livestock
++	Increased wood production, including fuelwood
++	Increased farm income: cash crop introduction

Production and socioeconomic disadvantages

---	Increased inputs including labour constraints constrain the technology being established
-	Increased inputs are required during maintenance of the technology

Socio-cultural benefits

+++	Strengthened community institution by way of community resource mobilisation (e.g. as a result of common establishment activities and visits to the site by outsiders)
+++	Improved knowledge about SWC and erosion
++	Improved health (due to cardamom's medicinal value)
++	Strengthened national institution (District Soil Conservation Office, Kathmandu)

Socio-cultural disadvantages

--	Socio-cultural conflicts
--	Other people may illegally extract non-timber forest products (because of remoteness)

Ecological benefits

+++	Soil and water conservation along with improved cover
+++	Reduced soil loss from approx. 200 t/ha/year to only 10 t/ha/year
+++	Stabilised slopes
++	Increased soil fertility
++	Increased Soil moisture
++	More efficient drainage of excess water
++	Springs protected (increase of water quantity/more steady flow)
+	Enhanced biodiversity

Ecological disadvantages

--	Increased soil erosion and sediment transport (locally) during establishment of structural measures

Off-site benefit

+++	Stabilisation of off-site agricultural land
++	Reduced downstream siltation
++	Reduced runoff/transported sediments
+	Reduced river pollution due to reduced turbidity
+	Increased stream flow in dry season
+	Reduced down stream flooding

Off-site disadvantages

-	Grazing pressure will increase elsewhere as the SWC site is closed to grazing

* All changes in technology may have gender and equity implications and potentially affect the members of disadvantaged groups differently. This has not been assessed here but should be considered when recommending technology use.

Concluding statements

Strengths and ➔how to sustain/improve	**Weaknesses** and ➔how to overcome
The technology requires resources which are largely locally available and of low cost ➔Raise awareness that landslide threatened stream banks and steep slopes can be protected using local resources.	Establishment costs are high ➔ Subsidise the cost (extension service, projects), reduce establishment costs by designing alternative structural measures that do not use cement
The technology addresses livelihood constraints ➔Raise awareness that the technology is profitable	Socioeconomic conflicts can arise when the value of land is raised ➔Take equity issues into account when implementing such a programme, and spread the benefits
Family members have learnt the technology; it is easy to replicate ➔Provide training to farmers to spread this information to others (e.g. through village initiatives supported by the government)	Establishment is very labour intensive
Better environment, increased biodiversity ➔As above	The technology is adopted more by better-off farmers ➔Government programmes should seek to involve poor farmers in land development with incentives for adopting recommended technologies
Soil and water conservation➔ As above	
Fresh products, health benefits from cardamom ➔ As above	
Income generation from cash cropping of cardamom, bamboo, broom grass ➔ As above	

Key reference(s): IBIWMP (2003) *Engineering Field Manual.* Kathmandu: Government of Nepal, Department of Soil Conservation and Watershed Management Programme, Bagmati Integrated Watershed Management ■ Howell, J. (ed) (1999) *Roadside Bio-engineering Reference Manual.* Kathmandu: Government of Nepal, Department of Roads

Contact person(s): HIMCAT/WOCAT Coordinator, International Centre for Integrated Mountain Development (ICIMOD), GPO Box 3226, Kathmandu, Nepal, himcat@icimod.org

Left: Eyebrow pit and drainage trench with grasses along the ridges of eyebrows and trenches (K.M. Sthapit)
Right: View of degraded site before rehabilitation (PARDYP photo file) and after two years of rehabilitation (K.M. Sthapit)

Rehabilitation of degraded communal grazing land

Nepal: क्षतिग्रस्त सामुदायिक चरण भूमिको पुनर्उत्थान

Rehabilitation measures, including eyebrow pits and live fencing, were implemented on degraded communal grazing land to reestablish a protective vegetative cover

An area of heavily degraded grazing land was rehabilitated by establishing eyebrow pits to control and harvest runoff, planting trees and grasses, and fencing the site to control grazing. The main purpose was to re-establish vegetative cover on the almost bare, overgrazed site. The site is community land of the 40 households (240 people) of Dhotra village in the Jhikhu Khola watershed. These people are very dependent on this area due to the lack of alternative grazing sites. The rehabilitation site is surrounded by irrigated cropland downstream, grazing land, and degraded sal *(Shorea robusta)* dominated forest. Rainfed forward-sloping terraces immediately adjoin the site.

About 130 eyebrow pits were dug, together with catch drainage trenches. Several species of grass and fodder were planted along the ridges of the eyebrows and drainage trenches. Contour hedgerows were established between the eyebrow pits and trenches, and trees were planted just below the pits. The maintenance is quite easy: the vegetation needs to be cut back from time to time and the pits cleaned before the pre-monsoon period. The remaining bare areas should be revisited each year and replanted.

The area has a distinct dry season from November to May and a wet monsoon period from June to October. Annual rainfall is around 1200 mm. The site has red soils that are highly weathered and, if not properly managed, are very susceptible to erosion.

WOCAT database reference: QT NEP13
Location: Dhotra village, Jhikhu Khola watershed, Kabhrepalanchok district, Nepal
Technology area: ~ 0.019 km^2
SWC measure: Structural, vegetative, and management
Land use: Grazing land
Climate: Humid subtropical
Related approach: Local initiatives for rehabilitation of degraded communal grazing land, QA NEP13
Compiled by: Nicole Guedel, Switzerland
Date: November 2004, updated October 2006

The technology was documented using the WOCAT (www.wocat.org) tool.
ICIMOD
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Swiss Agency for Development and Cooperation SDC
WOCAT

Classification

Land use problems

The major land use problem is the small per capita landholding size for cropping. These holdings are mostly rainfed, have a low soil fertility status and acidity problems, and are susceptible to erosion. Intense rainfall at the beginning of the rainy season causes considerable soil loss (rill and gully erosion).

Land use | **Climate** | **Degradation** | **SWC measures**

Grazing land: extensive grazing

Humid subtropical

Water erosion: loss of top soil and offsite degradation effects

Physical deterioration: aridification and soil moisture problem

Structural: eyebrow pits with drainage chanels

Vegetative: hedgerows across slope

Management: live fence

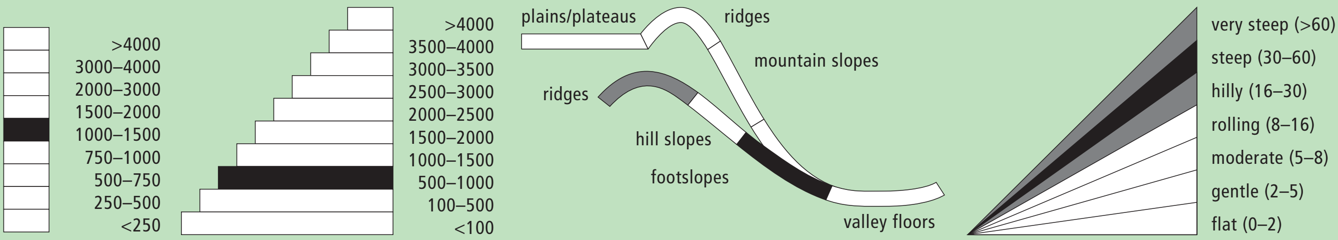
Technical function/impact

Main:
- harvesting of water
- improvement of ground cover
- increase/maintenance of water stored in soil

Secondary:
- reduction of slope angle
- reduction of slope length
- increase in organic matter

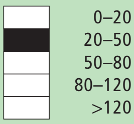
Environment

Natural environment



Applied (large extent) Applied (medium extent)

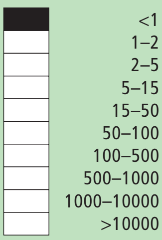
Soil depth (cm)



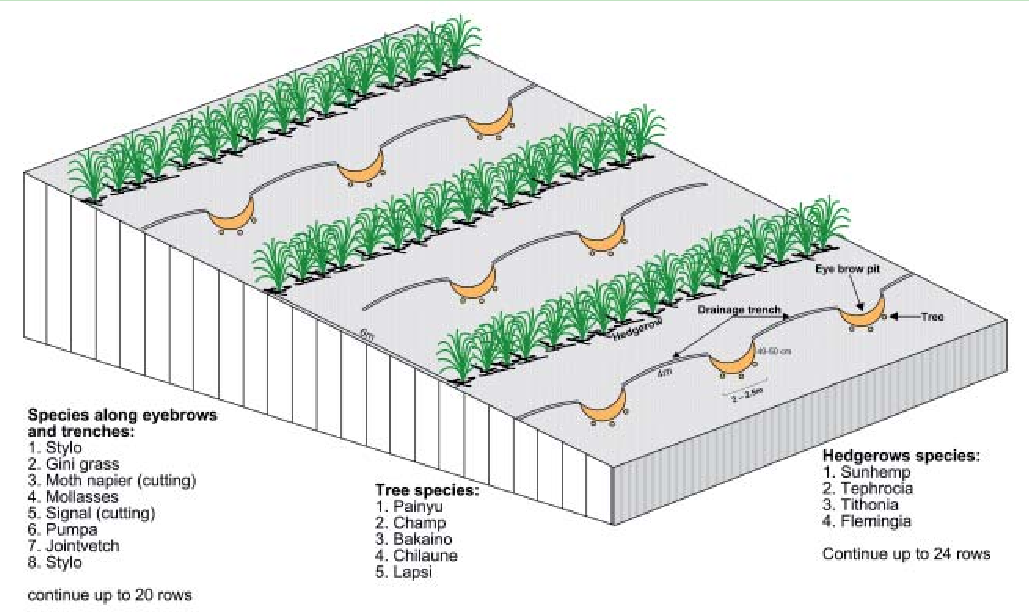
Growing season: 150 days (June to October) and 120 days (November to February)
Soil fertility: very low before implementation of rehabilitation activities
Soil texture: mostly fine (clay), red soils with high clay content
Surface stoniness: some loose stone
Topsoil organic matter: low
Soil drainage: poor
Soil erodibility: very high

Human environment

Grazing land per household (ha)



Land use rights: communal (organised)
Land ownership: state
Market orientation: subsistence (self-supply)
Level of technical knowledge required: field staff/extension worker: low, land user: low
Number of livestock: not relevant
Importance of off-farm income: in most farm households, off-farm income plays at least a minor and increasingly a major role. Occasional opportunities for off-farm income present themselves in the form of daily labour wages. Some households' members receive regular salaries, whilst an increasing number of Nepalis are working in India, the Middle East, Malaysia, and elsewhere and sending remittance incomes home.



Technical drawing
Technical drawing of layout of vegetative and structural measures

Implementation activities, inputs and costs

Establishment activities

Rehabilitation activities for the following three measures were carried out in June before the onset of the monsoon using local agricultural tools and manual labour.

Activities for structural measures:

1. Drawing layout of eyebrow terraces, drainage ditches, and hedgerows on the bare land
2. Digging holes for eyebrow pits, and drainage ditches using hoe and spade

Activities for vegetative measures:

1. Planting of tree seedlings and cuttings and sowing grass seeds using hoe and spade

Activities for management measures:

1. Making sure that all livestock are stall-fed
2. Establishing small live fences with grasses and shrub cuttings

Establishment inputs and costs per ha (2004)

Inputs	Cost (US$)	% met by land user
Labour (52 person days)	104	100%
Agricultural		
- Fertilizer	12	0%
- Grass seeds	6	0%
- Grass seedlings	23	0%
Others		
- Transportation	41	
- Lunch and tea for farmers	47	
TOTAL	**233**	**45%**

Maintenance/recurrent activities

1. Cleaning of sediment-filled pits once a year before rainy season using manual labour and a spade and hoe
2. Cutting vegetation with a sickle three times per year
3. Each year, planting vegetation in any gaps before the monsoon using a spade

Maintenance/recurrent inputs and costs per ha per year (2004)

Inputs	Cost (US$)	% met by land user
NA		

Remarks: All costs and amounts were roughly estimated by the technicians and authors in 2004, exchange rate was US$1 = NRs 73.

Assessment

Acceptance/adoption

About 40 households actively participated during the rehabilitation activities and accepted the technology. Seeds, seedlings, and technical advice were provided by the project as incentives. Most of the grazing land users were also members of the local community forest user group, which is considering using a similar technology in the degraded parts of their forest. However, up to 2006, there was no spontaneous adoption of the technology. The technology benefits women as it increases fodder and fuelwood production near to their homes and reduces the time they have to spend fulfilling these basic needs. Women's priorities were considered while selecting the plant species; species preferred by women were *Michelia champaca, Melia azedarach, Schima wallichii, Choerospondias axillaris, Azadirachta indica* and *Emblica officinalis.*

Drivers for adoption

- Participation of land users
- Technical backstopping in the initial stages
- Need-based technology

Constraints to adoption

- Lack of seeds and seedlings
- Difficult for users to know where and how to start to rehabilitate a large site

Benefits/costs according to land users

The high establishment costs of the technology means that the short-term benefit for the community only matches the costs involved. In the long-term the environmental benefit of rehabilitated land is high and economically it is positive.

Benefits compared with costs	short-term	long-term
establishment	equal	positive
maintenance/recurrent	equal	positive

Impacts of the technology*

Production and socioeconomic benefits

+ Increased carrying capacity of land; increase in farm income – about $17 was collected from selling grass seeds and grass in the first 2 years

Production and socioeconomic disadvantages

none

Socio-cultural benefits

+++ Strengthened community institution – money used for social work

+++ Improved knowledge of soil and water conservation and erosion

Socio-cultural disadvantages

- Socio-cultural conflicts, at the beginning a few people were against the rehabilitation

Ecological benefits

+++ Improved soil cover: about 80% of bare land covered by the various grasses

+++ Increased soil moisture

++ Reduced soil loss

++ More efficient drainage of excess water

++ Biodiversity enhanced

Ecological disadvantages

none

Off-site benefit

none

Off-site disadvantages

none

* All changes in technology may have gender and equity implications and potentially affect the members of disadvantaged groups differently. This has not been assessed here but should be considered when recommending technology use.

Concluding statements

Strengths and → how to sustain/improve	**Weaknesses** and → how to overcome
The technology package is easy to apply as it does not need much knowledge and is cost effective → Regular maintenance of the structure and grasses is required	None
Improvement can be seen fast and easily; the vegetation cover increased and the loss of top soil decreased → As above	
Reduced soil erosion, rill erosion, and top soil loss → As above	
The technology is effective against land degradation → More tree and fruit species should be added and grass species multiplied to cover the remaining bare land	

Key reference(s): Nakarmi, G. (2000) *Soil Erosion Dynamics in the Middle Mountains of Nepal,* a report submitted to PARDYP, ICIMOD, Kathmandu ■ Schreier, H.; Brown, S.; Shah, P. B.; Shrestha, B.; Merz, J. (2002) *Jhikhu Khola Watershed – Nepal,* CD ROM. Vancouver: Institute for Resources and Environment, University of British Columbia ■ Shrestha, B. (2004) Progress Report PARDYP-Nepal. Paper presented at the PARDYP – Access Mid Year Meeting, 19-22 July 2004, ICIMOD, Kathmandu

Contact person(s): HIMCAT/WOCAT Coordinator, International Centre for Integrated Mountain Development (ICIMOD), GPO Box 3226, Kathmandu, Nepal, himcat@icimod.org

Gully plugging using check dams

Nepal: गल्छी नियन्त्रण

Left: View of the case study gullies with check dams; inset – local people building the check dams (PARDYP)
Right: One of the gullies two years after the check dams were built (S.K. Bhuchar)

Small dam structures constructed across erosion gullies

Check dams are small low structures built across a gully or a channel to prevent them from deepening further. These small dams reduce the speed of water flow and minimise the erosive power of runoff. They also promote the deposition of eroded materials to further stabilise the gullies.

Two gullies adjacent to a degraded area of communal grazing land were controlled by constructing check dams and with vegetative measures including planting bamboo. The main purpose was to control the further development of the gullies, which were affecting the adjacent grazing land and blocking a downstream irrigation channel. The site is community land used by the 40 households (240 people) of Dhotra village in the intensively used Jhikhu Khola watershed. Irrigated cropland lies downstream from the site, whilst the site itself is bordered by grazing land, degraded sal-dominated forest, and rainfed forward-sloping terraces.

The check dams were made of old cement bags filled with soil and were 1m high with 0.5m deep foundations. The check dams were spaced so that a line joining the top of two adjacent dams had about a 3% slope gradient. Twenty-four check dams were built in the two gullies using a total of 2400 filled cement bags. Forty clumps of bamboo were planted between the dams for stabilisation.

All that is needed to maintain this technology is to inspect the condition of the check dams occasionally, especially before and after the monsoon. Displaced bags should be replaced and the water courses cleared of branches and big stones. Further planting should be carried out if needed.

The case study area has a distinct dry season from November to May and a wet monsoon period from June to October. Annual rainfall is around 1200 mm. The site has red soils that are highly weathered and, if not properly managed, are very susceptible to erosion.

WOCAT database reference: QT NEP14
Location: Dhotra village, Jhikhu Khola watershed, Kabhrepalanchok, Nepal
Technology area: ~ 0.006 km^2
SWC measure: Structural and vegetative
Land use: Grazing land
Climate: Humid subtropical
Related approach: Local initiatives for rehabilitation of degraded communal grazing land, QA NEP13
Compiled by: Nicole Guedel, Switzerland
Date: November 2004, updated June 2006

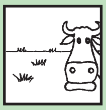
The technology was documented using the WOCAT (www.wocat.org) tool.

Classification

Land use problems

The major land use problem is the small per capita landholding size for cropping. These holdings are mostly rainfed, have a low soil fertility status and acidity problems, and are susceptible to erosion. Intense rainfall at the beginning of the rainy season causes considerable soil loss (rill and gully erosion).

Land use



Grazing land: extensive grazing

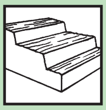
Climate

Humid subtropical

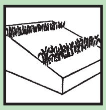
Degradation

Water erosion: loss of top soil, gully erosion, and off-site degradation effects

SWC measures



Structural: checkdams across gullies



Vegetative: shrubs, tree planting below checkdams

Technical function/impact

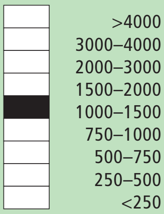
Main: - sediment harvesting
- control of concentrated runoff (impedes and retards)

Secondary: - reduction of slope angle
- increase in infiltration

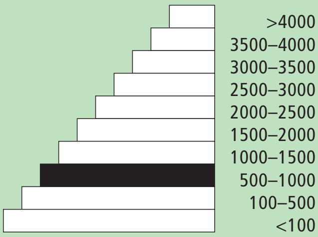
Environment

Natural environment

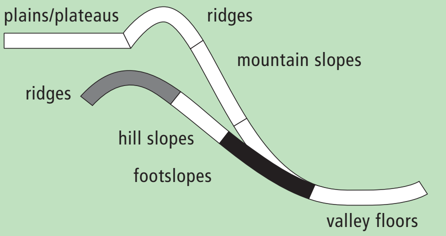
Average annual rainfall (mm)



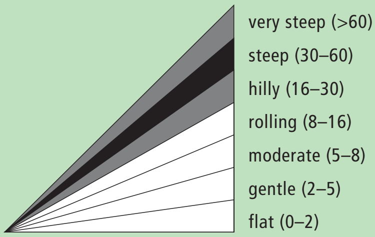
Altitude (masl)



Landform

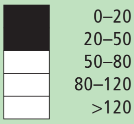


Slope (%)



Applied (large extent) Applied (medium extent)

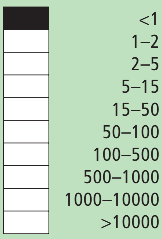
Soil depth (cm)



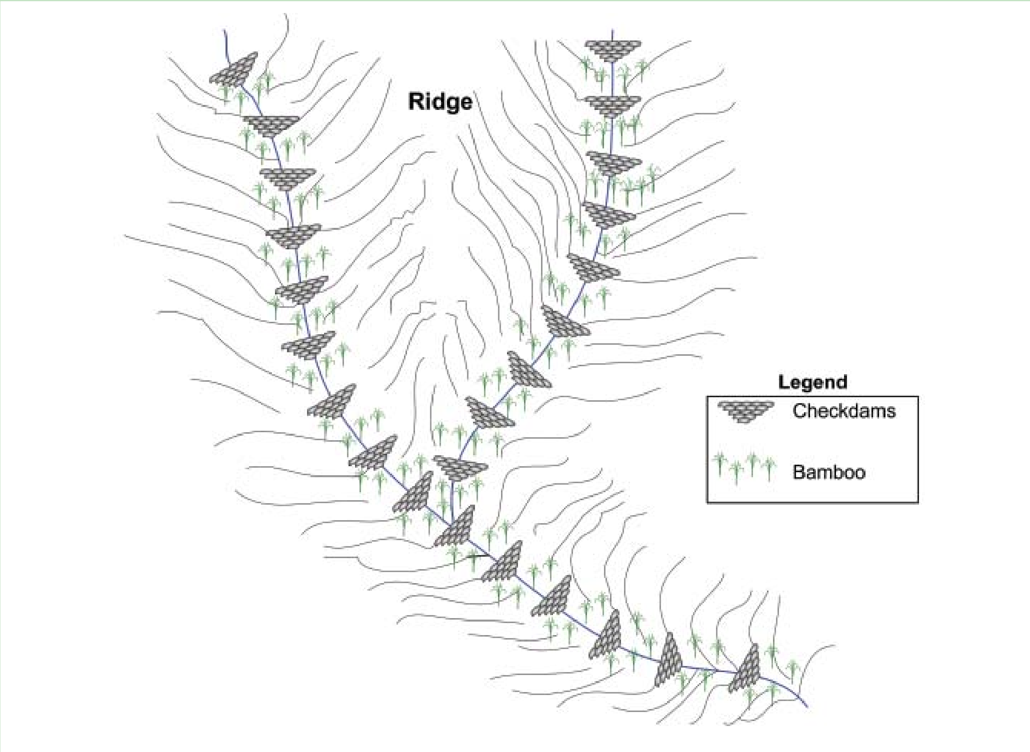
Growing season: 150 days (June to October) and 120 days (November to February)
Soil fertility: very low, before implementation of rehabilitation activities
Soil texture: mostly fine (clay), red soils with high clay content
Surface stoniness: some loose stone
Topsoil organic matter: low
Soil drainage: poor
Soil erodibility: very high

Human environment

Mixed land per household (ha)



Land use rights: communal (organised)
Land ownership: state
Market orientation: subsistence for self-supply
Level of technical knowledge required: field staff/extension worker: low, land user: low
Number of livestock: not relevant
Importance of off-farm income: in most farm households, off-farm income plays at least a minor and increasingly a major role. Occasional opportunities for off-farm income present themselves in the form of daily labour wages. Some households' members receive regular salaries, whilst an increasing number of Nepalis are working in India, the Middle East, Malaysia, and elsewhere and sending remittance incomes home.



Technical drawing
Schematic drawing of two gullies with 24 check dams and bamboo planted below the check dams for stabilisation

Implementation activities, inputs and costs

Establishment activities

Rehabilitation activities for the following two measures were carried out before the monsoon (June) using local agricultural tools and manual labour.

Structural measures:
1. Filling cement bags with soil
2. Digging trenches for dam foundations
3. Placing filled cement bags across gullies to form check dams

Vegetative measures:
1. Planting of bamboo plants (clumps) below the check dams

Establishment inputs and costs per ha (2004)

Inputs	Cost (US$)	% met by land user
Labour (18 person days)	36	100%
Materials		
- Cement bags (2400)	73	0%
Others		
- Transportation	14	0%
- Lunch, tea for farmers	16	0%
TOTAL	**139**	**25%**

Maintenance/recurrent activities

1. Maintaining gullies: repair or replace damaged check dams, plant more grasses or trees if needed
2. Ensuring good drainage for bamboo

Maintenance/recurrent inputs and costs per ha per year

Inputs	Cost (US$)	% met by land user
NA		

Remarks: All costs and amounts are roughly estimated by the technicians and authors, exchange rate US$1 = NRs 73 in 2004

Assessment

Acceptance/adoption

About 40 households were involved in building the dams and planting the bamboo, and accepted the technology. Empty cement bags and technical advice were provided by the project as incentives. Most of the grazing land users are also members of the local community forest user group and are considering using a similar technology in the degraded parts of their forest. However, up to 2006 there seemed to be no spontaneous adoption of this technology.

Drivers for adoption

- Raising awareness about the benefits of gully plugging
- Community mobilisation
- Participatory activities
- Technical support in the initial stages

Constraints to adoption

- Difficult for local people to know where to start to tackle large problems

Benefits/costs according to land users

Due to the high establishment costs, the short term benefit for the community only matches the costs. However, in the long-term the environmental benefit of rehabilitated land is high, and economic benefit is positive.

Benefits compared with costs	short-term	long-term
establishment	equal	positive
maintenance/recurrent	equal	positive

Impacts of the technology*

Production and socioeconomic benefits

none

Production and socioeconomic disadvantages

none

Socio-cultural benefits

+ + + Strengthened community institution

+ + + Improved knowledge of soil and water conservation and erosion

Socio-cultural disadvantages

- Socio-cultural conflicts; in the beginning a few people opposed the activities

Ecological benefits

+ + + Improved soil cover

+ + + More efficient drainage of excess water

+ + + Reduced soil loss

+ + Enhanced biodiversity

Ecological disadvantages

none

Off-site benefit

+ + + Reduced downstream siltation into irrigation canal

Off-site disadvantages

none

* All changes in technology may have gender and equity implications and potentially affect the members of disadvantaged groups differently. This has not been assessed here but should be considered when recommending technology use.

Concluding statements

Strengths and ➔how to sustain/improve	**Weaknesses** and ➔how to overcome
Low cost technology, easy to apply, little knowledge needed ➔ Regular maintenance of the structure and grasses is required	None
The effect of the technology can be seen easily ➔As above	
Reduced soil erosion, rill erosion, and top soil loss ➔As above	
The technology is easy to maintain ➔As above	

Key reference(s): Nakarmi, G. (2000) *Soil Erosion Dynamics in the Middle Mountains of Nepal,* a report submitted to PARDYP, ICIMOD, Kathmandu ■ Schreier, H.; Brown, S.; Shah, P. B.; Shrestha, B.; Merz, J. (2002) *Jhikhu Khola Watershed* – Nepal, CD ROM. Vancouver: Institute for Resources and Environment, University of British Columbia ■ Shrestha, B. (2004) *Progress Report PARDYP- Nepal.* Paper presented at the PARDYP Access Mid Year Meeting, 19-22 July 2004, ICIMOD, Kathmandu

Contact person(s): HIMCAT/WOCAT Coordinator, International Centre for Integrated Mountain Development (ICIMOD), GPO Box 3226, Kathmandu, Nepal, himcat@icimod.org

Left: Rice transplantation following the SRI method with young seedlings planted carefully and quickly to put minimum stress on the roots, planted singly to avoid root competition; and planted at a wide spacing to encourage greater root and canopy growth (Madhav Dhakal)
Right: Harvested SRI rice, the grain yield is higher than for traditionally grown rice (Madhav Dhakal)

System of Rice Intensification (SRI)

Nepal: धान उत्पादन वृद्धि गर्ने तरीका

A method for increasing the productivity of rice by changing the management of plants, soil, water, and nutrients

The System of Rice Intensification (SRI) was developed in Madagascar by Henri de Laulanie, in the 1980s. He worked with Malagasy farmers and colleagues to improve the possibilities of rice production. The practice contributes to both healthier soil and healthier plants, supported by greater root growth and the nurturing of soil microbial abundance and diversity. It is based on a number of well-founded agroecological principles. SRI concepts and practices have also been successfully adapted to upland rice.

SRI involves transplanting very young rice seedlings (usually 8-12 days old with just two small leaves) carefully and quickly so as to cause minimum disturbance to the roots. The seedlings are planted individually, in contrast to the traditional method where clumps of 3-4 are planted together, minimising root competition between the seedlings. The seedlings are kept widely spaced to allow better root and canopy growth, in a square grid pattern at a spacing of at least 25 x 25 cm. Planting can be done even wider at 30 x 30 or 40 x 40 cm and even up to 50 x 50 cm in the best quality soils.

The soil is kept moist but well drained and aerated to support increased biological activity. A small quantity of water is applied during the vegetative growth period following which a thin layer of water is maintained on the fields only during the flowering and grain-filling stages. Better quality compost, such as well decomposed farmyard manure, can be applied to achieve additional yield increases. Since weed growth will be more abundant and will be a problem in fields that are not kept flooded (and because of the wider spacing), weeding needs to be done at least once or twice in the first 10-12 days and a total of three or four times altogether before the canopy closes.

SRI does not require additional inputs like new seeds, chemical fertiliser or pesticides, but it does require the skilful management of the factors in production and, at least initially, 25-50% more labour inputs, particularly for the transplanting and weeding. As farmers become more skilled and confident in SRI, the amount of labour needed decreases and can eventually become the same or even less than with conventional methods.

SRI is being tried out by farmers in many areas of Nepal's middle mountains including in the Jhikhu Khola watershed. This area has an altitude of 800-2200 masl, and receives about 1200 mm annual rainfall, about 70-80% in the monsoon months (June to September).

WOCAT database reference: QT NEP15
Location: Panchkhal, Hokse, Bhimsensthan, Baluwa, and Patalekhet VDCs in the Jhikhu Khola watershed, Kabhrepalanchok district, Nepal
Technology area: ~ 0.1 km^2
SWC measure: Management
Land use: Annual cropping
Climate: Humid subtropical
Related approach: Evaluation of SRI through participatory research and development approach, QA NEP15
Compiled by: Madhav Dhakal, ICIMOD
Date: June 2006, updated November 2006

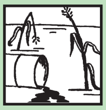
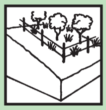
General comments: SRI is an innovation rather than a technology. It is gaining popularity all over the world. Increased yields of 50-100% have been reported in most places where it has been tried. The practice is gaining popularity in Nepal especially in the eastern Terai plains.

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

Classification

Land use problems

Limited production due to soil fertility decline, increased amount of agrochemical inputs and lack of sufficient irrigation water and irrigation infrastructures.

Land use	Climate	Degradation		SWC measures
				
Annual crops: maize (before SWC),vegetables and rice (after SWC)	Humid subtropical	Chemical deterioration: fertility decline and reduced organic matter content	Water erosion: terrace collapse due to stagnent water	Management: different planting, irrigation and soil fertility management method

Technical function/impact

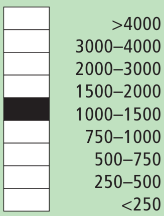
Main:
- improved plant management
- improved water management
- improved soil management

Secondary:
- increase in soil fertility
- increase in organic matter

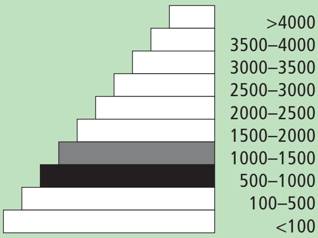
Environment

Natural environment

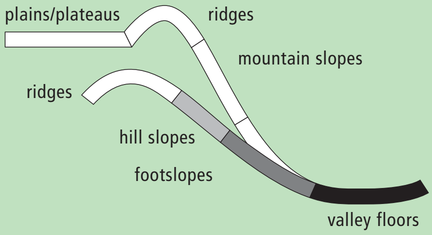
Average annual rainfall (mm)



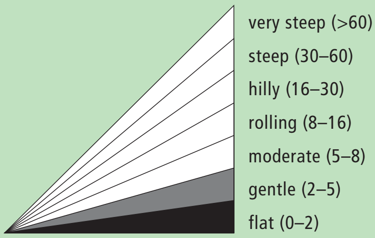
Altitude (masl)



Landform

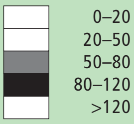


Slope (%)



Applied (large extent) Applied (medium extent) Applied (small extent)

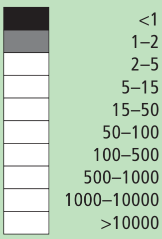
Soil depth (cm)



Growing season: 150 days (June to October) and 120 days (November to February)
Soil fertility: low to very low
Soil texture: mostly fine (clay), medium
Surface stoniness: mostly no loose stones
Topsoil organic matter: low to medium
Soil drainage: mostly medium, poor
Soil erodibility: medium

Human environment

Cropland per household (ha)



Land use rights: individual
Land ownership: individually owned/titled
Market orientation: subsistence (self-supply)
Level of technical knowledge required: field staff/extension worker: moderate, land user: low
Number of livestock: not relevant
Importance of off-farm income: in most farm households, off-farm income plays at least a minor and increasingly a major role. Occasional opportunities for off-farm income present themselves in the form of daily labour wages. Some households' members receive regular salaries, whilst an increasing number of Nepalis are working in India, the Middle East, Malaysia, and elsewhere and sending remittance incomes home.

Technical drawing
In the SRI method young seedlings (8-12 days old) are planted singly at a wide spacing of 25 x 25 cm or more

Implementation activities, inputs and costs

Establishment activities

Most of the farmers were already planting rice and rice fields did not need to be established.

Establishment inputs and costs per ha (2006)

Inputs	Cost (US$)	% met by land user
Note: SRI was tested mostly on traditional irrigated fields and in a few cases on traditional rainfed terraces meaning that all the field activities for the SRI method were regular annual operations.		

Maintenance/recurrent activities

1. Nursery bed preparation, seed treatment, and sowing: generally performed at the beginning of the monsoon season
2. Main field preparation (ploughing and levelling): generally performed at the beginning of the monsoon season
3. Transplantation: in monsoon, 8 to 12 days after seed sowing
4. Irrigation of the main fields (to keep fields alternately dry and moist) weekly after transplantation; during the flowering stage a depth of at least 2 cm of water is needed
5. Weeding: 3-4 times – firstly within the first 10 days and a further 2-3 times at 14-day intervals
6. Application of fertiliser
7. Application of pesticides (if required)
8. Harvesting: in October/November

Most of the work is performed manually using locally available agricultural tools like ploughs, levellers and spades

Maintenance/recurrent inputs and costs per ha per year (2006)

Inputs	Cost (US$)	% met by land user
Labour (449 person days)	740	100%
Equipment (machine hours)	136	100%
Agricultural		100%
Materials		
- Seeds (18 kg)	4	
- Fertilizer (301 kg)	94	
- Biocides (2 l)	56	
TOTAL	**1030**	**100%**

Remarks: All costs and amounts were roughly estimated by the technicians and the author (extrapolated from an area of 215 m²), exchange rate US$1 = NRs 73 in 2006

Assessment

Acceptance/adoption

In the case study area only six farmers adopted SRI in 2003. By 2005, 35 farmers had spontaneously adopted the method, and interest in SRI in the Jhikhu Khola watershed is growing. Farmers are adopting the SRI method carefully and slowly by at first only putting small areas under SRI and then slowly increasing the area planted.

Drivers for adoption

- Demonstration and extension of the technique through participatory research and development

Constraints to adoption

- Requires more labour for weeding
- Uncertain rainfall during transplanting period

Benefits/costs according to land users

If rice fields need to be established, the short-term establishment costs and the benefits realised are about the same. However, most farmers already had rice fields and therefore the benefits are more than the costs.

Benefits compared with costs	short-term	long-term
establishment	equal	positive
maintenance/recurrent	positive	positive

Impacts of the technology*

Production and socioeconomic benefits

- ++ Increased crop yield: increased grain yield
- ++ Increased quantity and quality of fodder: increased above ground biomass
- ++ Increased farm income due to increased grain and biomass; savings on seed, fertiliser, and labour

Production and socioeconomic disadvantages

- \- Increased labour constraints: only the first weeding is labour intensive

Socio-cultural benefits

- +++ Improved knowledge of soil and water conservation and erosion: use of organic fertiliser, reduced chemical fertiliser application, different method of irrigation management adopted
- +++ Strengthened community institution: joint planning, discussing in a group and implementing the method systematically

Socio-cultural disadvantages

none

Ecological benefits

- \+ Increased soil fertility: use of organic fertiliser, reduced chemical fertiliser application

Ecological disadvantages

none

Off-site benefit

- \+ More irrigation water available for downstream use: SRI uses less water than traditional method

Off-site disadvantages

none

* All changes in technology may have gender and equity implications and potentially affect the members of disadvantaged groups differently. This has not been assessed here but should be considered when recommending technology use.

Concluding statements

Strengths and ➔how to sustain/improve	**Weaknesses** and ➔how to overcome
Compared to the traditional method, SRI consumed 50 to 75% less water, 75% less seed, 50% less labour for transplanting, 50-60% less labour for irrigation, and less pesticide; the cost of fertiliser and harvesting remained the same, thus the overall cost of production is the same or a little less ➔More experience sharing would help expand the area under SRI	Water control is the most difficult part of this method; to maintain alternate dry and moist field conditions, water needs to be available at 5-6 day intervals ➔ There needs to be good irrigation infrastructure or a perennial source of water to irrigate rice fields regularly
SRI method improved soil environment and reduced rates of riser collapse ➔Impact of long-term soil nutrient balance has yet to be studied	Transplanting 8-12 day old seedlings, especially under rainfed conditions, is quite difficult. Seedlings become old and unfit for transplanting when there is no rain during the transplanting time ➔ Establish two to three nursery beds at intervals of one week
40-50% more grain production and 20-25% increase in above ground biomass production compared to traditional method ➔ Experience sharing would help expand the area under SRI	This method is only suitable for smallholder farmers, in most countries it is not adopted on a large scale ➔ Involvement of national departments and local institutions and wider sharing of its proven benefits is vital to upscale the innovation
Conflict over water during irrigation time reduced ➔As above	Compared to the traditional method, the cost for weeding is 50-60% higher and the first weeding is difficult ➔ Overall cost remains the same

Key reference(s): ICIMOD (2007) *'Good Practices in Watershed Management, Lessons Learned in the Mid Hills of Nepal.* Kathmandu: ICIMOD ■ Uphoff, N. (2004) 'System of Rice Intensification Responds to 21st Century Needs'. In *Rice Today,* 3 (3):42 ■ IRRI International Rice Research Institute, www.irri.org.

Contact person(s): HIMCAT/WOCAT Coordinator, International Centre for Integrated Mountain Development (ICIMOD), GPO Box 3226, Kathmandu, Nepal, himcat@icimod.org

Left: Farmyard manure covered with a black plastic sheet. The sheet provides a favourable environment for the growth of microbes so that the manure decomposes faster compared to the traditional practice (K.M. Sthapit)
Right: Women carrying farmyard manure to the fields (K.M. Sthapit)

Black plastic covered farmyard manure

Nepal: कालो प्लास्टिकले छोपेको मल

Improving farmyard manure (FYM) by covering it with black plastic sheeting to provide a favourable environment for microbial activities, and to conserve available nutrients and moisture

Applying compost or farmyard manure (FYM) is an excellent way of maintaining and building soil fertility. Considerable nutrient losses often occur through the inappropriate handling or storage of compost and FYM. Drying out causes losses through volatilisation and rainfall whilst runoff causes leaching and the washing out of nutrients. To reduce nutrient losses, farmyard manure needs to be protected from direct sunlight, rainfall, run-on, and runoff.

A number of improved composting methods have been tested and demonstrated with farmers in the Jhikhu Khola watershed. The Sustainable Soil Management Project (SSMP) has recommended black plastic-covered farmyard manure as one of the most promising methods. Farmyard manure is covered with a piece of black plastic to prevent nutrients from leaching out, to decrease evaporation losses, and to provide a more favourable environment for the growth of microbes due to the increased temperature and moisture content. This method is especially suitable for areas with low temperatures.

In this method, raw organic materials that are used for animal bedding – crop residues, leaves, grass, weeds and other organic materials – are piled up or put into a pit in layers together with animal urine and dung. The pile is then completely covered with black plastic sheeting. This method is based on the passive aeration approach, the plastic sheet is removed from the heap each day to add more bedding materials. It is then covered again immediately. Maintenance is easy although care is needed to avoid damaging the sheet. The black plastic should be handled carefully while taking it off and returning it to the pile as the composting material may contain sharp-edged plant stems.

The method was found to be easy to apply and took little time and labour. In the Jhikhu Khola area, women are mainly responsible for preparing manure and carrying it to the fields. This technology reduces their burden as a smaller amount of black plastic FYM is needed to meet soil nutrient requirements compared to traditional FYM, which is normally applied in a poorly decomposed form and in large quantities.

The method was tested in the middle mountains of Nepal in the Jhikhu Khola watershed, located at 800-2200 masl and with 1200-1600 mm annual rainfall, about 70-80% in the monsoon months (June to September). The temperature ranges from 3-40^{0}C in the lower parts of the watershed and about 3^{0}C less at the higher elevations.

WOCAT database reference: QT NEP16
Location: Panchkhal, Patalekhet, Hokse, Baluwa, Sathighar, and Kabhre VDCs and Dhulikhel municipality of the Jhikhu Khola watershed, Kabhrepalanchok district, Nepal
Technology area: ~ 1-10 km^2
SWC measure: Management
Land use: Annual cropping
Climate: Humid subtropical
Related approach: Not described
Compiled by: Madhav Dhakal, ICIMOD
Date: November 2006

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

Classification

Land use problems

Crop production is limited as a result of soil fertility deterioration, high cropping intensity, and a scarcity of irrigation water. Application of increasing amounts of agrochemicals is further deteriorating soil health.

Land use

Annual crops: rainfed and irrigated

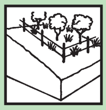
Climate

Humid subtropical

Degradation

Chemical deterioration: fertility decline and reduced organic matter content

SWC measures



Management: from traditional to improved

Technical function/impact

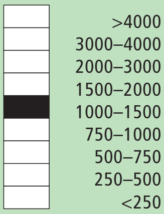
Main: - nutrient conservation
- accelerated decomposition

Secondary: - none

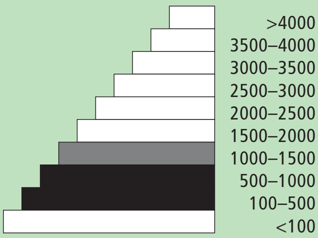
Environment

Natural environment

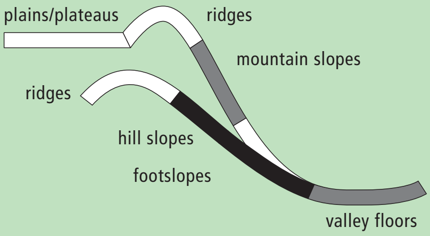
Average annual rainfall (mm)



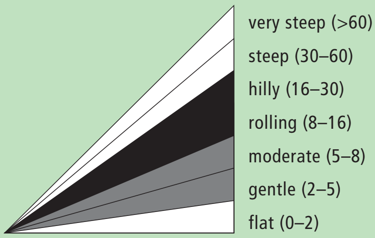
Altitude (masl)



Landform

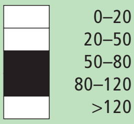


Slope (%)



Applied (large extent) Applied (medium extent)

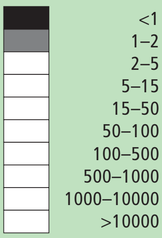
Soil depth (cm)



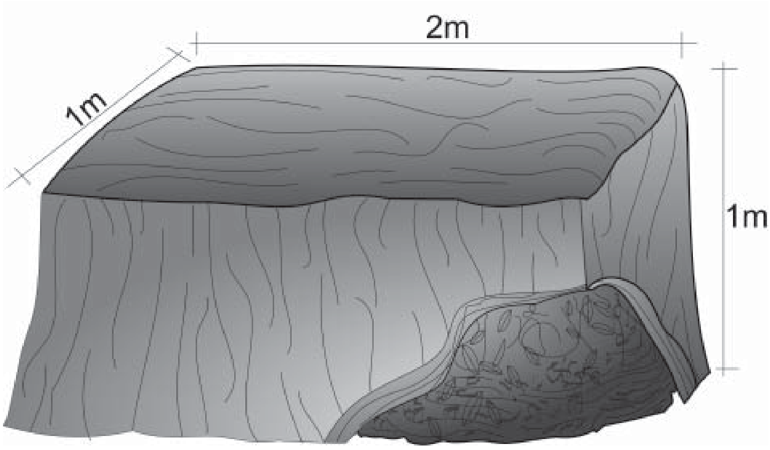
Growing season: 150 days (June to October) and 120 (November to February)
Soil fertility: very low to medium (variable)
Soil texture: fine to medium
Surface stoniness: with or without loose stones
Topsoil organic matter: low to medium
Soil drainage: poor to good
Soil erodibility: medium to high

Human environment

Cropland per household (ha)



Land use rights: individual
Land ownership: individually owned/titled
Market orientation: mostly subsistence (self-supply), some mixed subsistence and commercial (commercial is only growing vegetables)
Level of technical knowledge required: field staff/extension worker: low, land user: low
Number of livestock: 3.9 tropical livestock units (TLU) per household
Importance of off-farm income: in most farm households, off-farm income plays at least a minor and increasingly a major role. Occasional opportunities for off-farm income present themselves in the form of daily labour wages. Some households' members receive regular salaries, whilst an increasing number of Nepalis are working in India, the Middle East, Malaysia, and elsewhere and sending remittance incomes home.



Technical drawing
Black plastic covered farmyard manure

Implementation activities, inputs and costs

Establishment activities

The establishment activities are done using manual labour.

1. Bedding material (e.g. crop residues, leaves, grass, weeds) along with animal urine and dung, are piled near the cattle-shed
2. Each day farmers add bedding material to the piled heap or into the pit and replace the black plastic cover.

Establishment inputs and costs per unit technology (2006)

Inputs	Cost (US$)[1]	% met by land user
Materials		
- Black plastic sheet (5 kg)	17.6	0%
TOTAL	**17.6**	**0%**

[1] Exchange rate US$1 = NRs 73 in 2006

Maintenance/recurrent activities

Moisture and temperature is checked regularly

Maintenance/recurrent inputs and costs per ha per season (2006)

Inputs	Cost (US$)[1]	% met by land user
Labour (4 person days)	8.4	100%
TOTAL	**8.4**	**100%**

Remarks: The only establishment cost is the cost of the sheet. In this case study, a 5 kg black plastic sheet costing about $17.6 was used. This sheet was thick (800 microns thick) and is expected to last for 4-5 years. Less durable and smaller sheets cost less. Each day a farmer needs about 30 minutes to add bedding materials, equivalent to 4 person days per month for 2 months. The labour is mainly done by women and girls.

Assessment

Acceptance/adoption

About 50 households accepted the technology and tested it to make nutrient-rich farmyard manure. Spontaneous adoption of the technology was not seen as the sheeting was not locally available and also due to the lack of dissemination and awareness raising activities.

Drivers for adoption

- The technology is easy to handle and is durable, producing good quality FYM that is fine and well decomposed. This technology reduces women's (and men's) workload in preparing FYM and conserves nutrients.

Constraints for adoption

- Good quality black plastic sheets are not available locally and are relatively costly. This limits adoption, especially by poorer households.

Benefits/costs according to land users

The investment costs are paid back within the first year leading to positive results due to higher production due to more nutrient-rich compost.

Benefits compared with costs	short-term	long-term
establishment	positive	positive
maintenance/recurrent	positive	positive

Impacts of the technology

Production and socioeconomic benefits

- ++ Increased crop yields: farmers indicated that after applying the improved FYM (black plastic covered) crop yields increased compared to application of traditionally prepared FYM
- ++ Increased farm incomes from higher crop yield

Production and socioeconomic disadvantages

none

Socio-cultural benefits

- ++ Improved knowledge on nutrient status of improved and traditional FYM

Socio-cultural disadvantages

none

Ecological benefits

- ++ Increased soil fertility compared to traditional FYM; improved FYM is richer in nutrient content (N, P, K, organic matter, C/N ratio)

Ecological disadvantages

none

Off-site benefit

- ++ Kept village cleaner

Off-site disadvantages

none

Concluding statements

Strengths and ➔how to sustain/improve	**Weaknesses** and ➔how to overcome
FYM decomposes within 45-50 days compared to about 180 days with the traditional method; the improved FYM is very fine and with equal decomposition from top to bottom of the heap ➔Share experiences with a wider audience and test the technology in different ecological zones	Unavailability of large enough sheets to cover huge heaps ➔ Make two or more smaller heaps; or cover big heaps with two or more sheets
The quality of FYM is better than traditionally made FYM; nutrient content (N, P, K, organic matter, C-N ratio) is higher ➔ As above	Plastic sheet gets damaged if not handled carefully and is easily damaged by rats ➔ Handle sheets carefully and protect from rats using locally available rat repellent plants like *Artemisia indica* (titepati)
This method is very appropriate for high and middle mountain areas; black plastic is easy to handle, light, and durable ➔ As above	Poorer rural people are put off by the cost and unavailability of the sheets; they have to bear the extra cost of bringing sheet from afar ➔ Make the sheets available in the local market and arrange for the cost to be subsidised by agriculture departments and non-government organisations.
More production observed (especially for vegetables) with black plastic FYM compared to traditional FYM ➔ Carry out comparative production studies on more crops	
Less workload for women during FYM preparation and transportation ➔ Promote and implement the technology more	
The technology will promote organic production of desired crops as avoids the need for chemical fertilisers ➔ As above	

Key reference(s): ICIMOD (2007) *Good Practices in Watershed Management, Lessons Learned in the Mid Hills of Nepal.* Kathmandu: ICIMOD

Contact person(s): HIMCAT/WOCAT Coordinator, International Centre for Integrated Mountain Development (ICIMOD), GPO Box 3226, Kathmandu, Nepal, himcat@icimod.org

Left: Brick-cement walled spring box (check dams were established to prevent surface water flowing directly into the spring and contaminating it) (Sanjeev Bhuchar)
Right: Grass seedlings planted around the spring box (Madhav Dhakal)

Drinking water quality improvement through conservation measures

Nepal: संरक्षण विधिद्वारा पिउने पानीको गुणस्तर सुधार

Structural and vegetative measures to improve the quality of drinking water contaminated due to poor sanitation and seepage

This technology combines structural and vegetative measures to improve the quality of drinking water in an open spring. The quality of water was deteriorating due to poor sanitation and seepage around the spring. The spring was located near to Dhotra village at Barbot sub-settlement, Kabhrepalanchok district. About five households depended on the spring for their drinking water supplies with a further 10 using it regularly and 10-15 using it occasionally during the dry season.

The main purpose of implementing the technology was to improve the quality of drinking water in the spring by preventing it from being contaminated by surface runoff during the rainy season. This technology has long been implemented across Nepal's midhills. In this case a development project (PARDYP) mobilised the users and provided them with technical and material support to make the improvements.

A spring user group was formed. With project help, it built a walled structure (a spring box) over the spring and check dams around the spring, and planted grasses around the spring box and trees in the catchment. These measures prevented the direct flow of surface water into the spring thus reducing contamination and turbidity. Users built a 1.8m long, 1m wide and 1.5m high spring box with a zinc sheeted roof. Check dams were built across the surrounding gullies and rills. A main 2.5m long, 0.5m wide, and 1m high check dam was constructed near the source to prevent surface runoff from entering the spring. A drainage channel was made to drain off wastewater. Vetiver grass seedlings were planted around the spring box and trees were planted in the adjoining catchment. These activities were carried out at the beginning of the rainy season.

This technology is simple and durable and the only maintenance needed is to keep the surroundings clean and to repair any damage.

The case study area receives about 1200 mm of annual precipitation of which about 80% occurs during the monsoon season (June to September). The area mostly has red soils which are highly weathered and, if not managed properly, are very susceptible to erosive processes.

WOCAT database reference: QT NEP17
Location: Dhotra village, Jhikhu Khola watershed, Kabhrepalanchok district, Nepal
Technology area: < 0.1 km^2
SWC measure: Structural and vegetative
Land use: Extensive grazing
Climate: Humid subtropical
Related approach: Community effort for drinking water quality improvement, QA NEP17
Compiled by: Madhav Dhakal, ICIMOD
Date: : November 2006

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

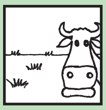
Classification

Land water use problems

High pressure on limited land resources due to overuse of crop, forest, and grazing lands; increased inputs of agro-chemicals which will lead to the deterioration of drinking water quantity and quality

Water quality deterioration resulting from poor sanitation

Land use



Grazing land: extensive grazing

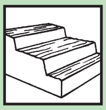
Climate

Humid subtropical

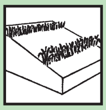
Degradation

Water erosion: loss of top soil, and offsite degradation effects

SWC measures



Structural: walls, check dams



Vegetative: grasses around structures

Technical function/impact

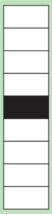
Main:
- control of concentrated runoff (impedes/retards)
- improvement of ground cover

Secondary:
- increase/maintain water stored in soil

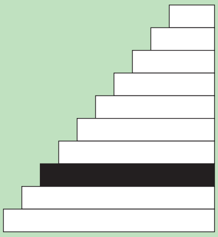
Environment

Natural environment

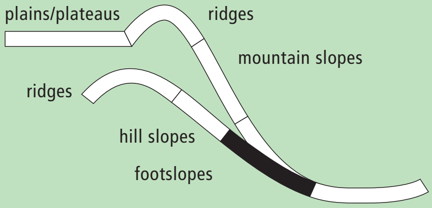
Average annual rainfall (mm)



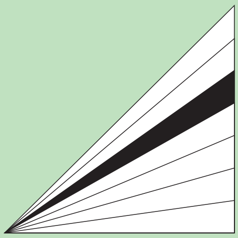
Altitude (masl)



Landform



Slope (%)



Applied (large extent)

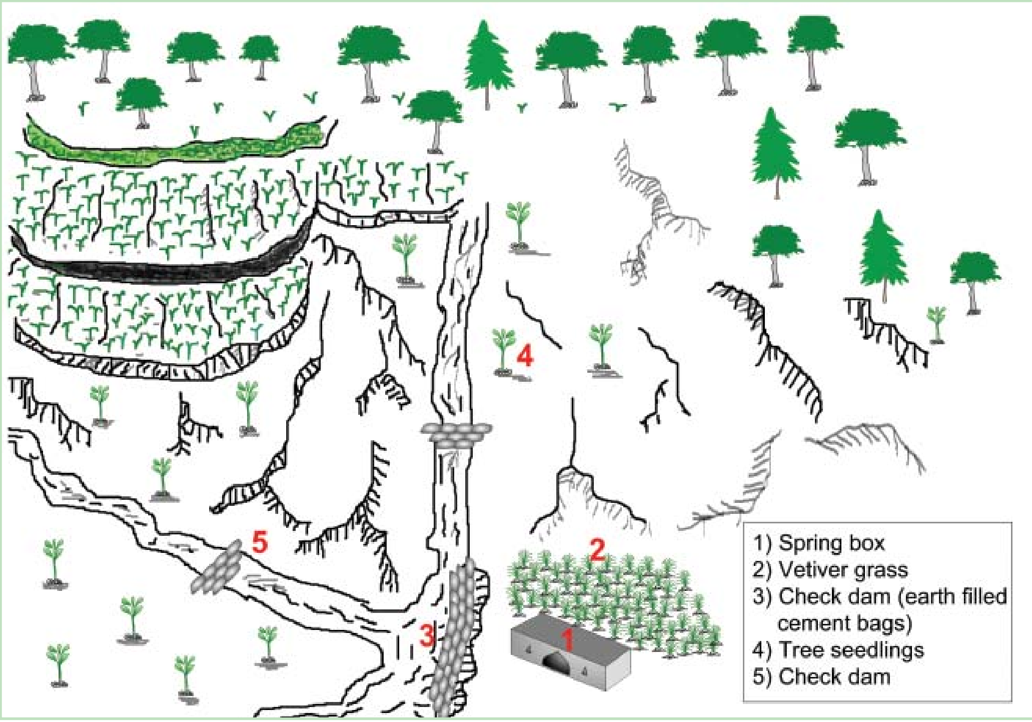
Soil depth (cm)

Growing season: 150 days (June to October) and 120 days (November to February)
Soil fertility: very low
Soil texture: mostly fine (clay)
Surface stoniness: some loose stone
Topsoil organic matter: low
Soil drainage: medium
Soil erodibility: very high

Human environment

Grazing land per household (ha)

Land use rights: individual
Land ownership: partly individually owned/titled and partly state owned
Market orientation: mostly subsistence (self-supply)
Level of technical knowledge required: field staff/extension worker: moderate, land user: moderate
Number of livestock: not relevant
Importance of off-farm income: in most farm households, off-farm income plays at least a minor and increasingly a major role. Occasional opportunities for off-farm income present themselves in the form of daily labour wages. Some households' members receive regular salaries, whilst an increasing number of Nepalis are working in India, the Middle East, Malaysia, and elsewhere and sending remittance incomes home.



Technical drawing
Structural and vegetative measures applied to improve water quality of spring

Implementation activities, inputs and costs

Establishment activities

The following tasks are carried out using manual labour and local agricultural tools (hoe, shovel, leveller, trowel nails, and a hammer). The work is usually done at the beginning of the rainy season.

1. Building of check dams to divert stream and gully runoff water
2. Building of the spring box
3. Construction of concrete floor in front of spring box
4. Construction of drainage channel
5. Planting vetiver grass around the spring box
6. Planting tree species in the catchment

Establishment inputs and costs per unit technology (2006)

Inputs	Cost (US$)	% met by land user
Labour (63 person days)	110	80%
Materials		
- Cement (400 kg)	44	0%
- Gravel and sand (2000 kg)	55	100%
- Bricks (2750 pieces)	188	0%
- Empty sacks (200 pieces)	5	0%
- Zinc sheet (4 pieces)	16	0%
- Steel wire	1	0%
Agricultural		
- Grass seedlings (250 pieces)	4	0%
Other		
- Transportation	10	15
TOTAL	**433**	**33%**

Maintenance/recurrent activities

Maintenance is carried out as needed using local agricultural tools.

- Cleaning spring box surroundings
- Maintenance of wall/floor against damage
- Maintenance of check dam against damage
- Replacement/gap filling with new tree seedlings
- Cutting planted grass

Maintenance/recurrent inputs and costs per year (2006)

Inputs	Cost (US$)	% met by land user
Labour (2 person days)	3.2	100%
TOTAL	**3.2**	**100%**

Remarks: Skilled labour was paid to build the spring box. Exchange rate US$1 = NRs 73 in 2006

Assessment

Acceptance/adoption

Fifteen families accepted the technology with incentives. Local people with inadequate access to drinking water or whose source is contaminated are likely to adopt the technology after raising the funds themselves.

Drivers for adoption

- Need for clean drinking water
- Fast impact visible, including improved water quality leading to improved health
- Easy to establish and no guidance is needed

Constraints to adoption

- Community has to get organized and collect enough money
- Too expensive for an ordinary single farmer

Benefits/costs according to land users

Clean water is available immediately after only a little investment. Government and PARDYP support meant that the short-term benefit was positive. Without this support the short-term costs would equal the benefits.

Benefits compared with costs	short-term	long-term
establishment	positive	very positive
maintenance/recurrent	very positive	very positive

Impacts of the technology

Production and socioeconomic benefits

none

Production and socioeconomic disadvantages

none

Socio-cultural benefits

+ + + Strengthened community institution due to formation of a user group; less conflicts for drinking water

+ + + Improved knowledge of soil and water conservation and erosion from group discussions and awareness raising activities

Improved health

Decreased women's workload for collecting water

Socio-cultural disadvantages

- - - Socio-cultural conflicts due to insufficient water quantity especially during dry and pre-monsoon months

Ecological benefits

+ + + Improved drainage of excess water due to the drainage trench and check dams

+ + Reduced soil loss reduction due to the check dams

+ Improved soil cover

Ecological disadvantages

none

Off-site benefit

none

Off-site disadvantages

none

Concluding statements

Strengths and → **how to sustain/improve**	**Weaknesses** and → **how to overcome**
Water turbidity decreased from 23 nephelometric turbidity units (NTU) in August 2004 to 7 NTU in August 2005 → Encourage spring users to plant more multiple grasses and tree species around the catchment area	Coliform bacteria are still a problem → Treat the water using SODIS, boiling, filters, chlorination or other methods before drinking
Faecal contamination decreased from 500 coliform formation units (CFU)/100 ml in August 2004 to 200 CFU/100 ml in August 2005. Similarly, the levels of ammonia (NH_3) and nitrate (NO_3 in the spring water have decreased (NH_3 from 0.5 to 0 mg/l; and NO_3 from 0.7 to 0.5 mg/l). Total hardness of spring water remained the same at 30 mg/l → Regular maintenance, especially cleaning the surrounding area is needed; also need a clean pot for extracting the water	The water available during the pre-monsoon season is insufficient for the 15 households, leading to conflicts; the water source can be contaminated from unclean water fetching pots → The water in the spring box should be siphoned into a storage tank fitted with an overflow mechanism, cleaning outlet, lockable cover, and taps. This would protect the water source from contamination from open access and improve the quality and availability of water. The amount available could be increased by tapping other spring sources
Increased availability of drinking water has reduced women's workload during the dry season → Improve the technology by building a closed storage tank	

Key reference(s): ICIMOD (2007) *Good Practices in Watershed Management: Lessons Learned in the Mid Hills of Nepal.* Kathmandu: ICIMOD

Contact person(s): HIMCAT/WOCAT Coordinator, International Centre for Integrated Mountain Development (ICIMOD), GPO Box 3226, Kathmandu, Nepal, himcat@icimod.org

Left: The three components of a roof rain-water harvesting system: a catchment roof, conveyance pipes, and a ferro-cement storage jar (K.M. Sthapit)
Right: Installing the mould and wrapping it in chicken mesh to make the jar (PARDYP)

Rooftop rainwater harvesting system

Nepal: आकाशे पानी संकलन प्रणाली

A water harvesting system in which rain falling on a roof is led through connecting pipes into a ferro-cement water collecting jar

Many households in Nepal's midhills suffer from water shortages during the pronounced dry season. The technology described here – harvesting roofwater during times of heavy rainfall for later use – is a promising way of improving people's access to water for household use, especially for households with no or only limited access to spring or stream water. The technology has yet to be extensively adopted Nepal's midhills.

The technology was introduced in the Jhikhu Khola watershed to demonstrate an alternative source of water for domestic use (mainly drinking water). This technology is appropriate for scattered rural households in mountainous areas. The harvesting system consists of a catchment roof, conveyance pipes, and a storage jar. The pipes include a gutter system made from longitudinally split polythene pipe which has a flushing system that allows the system to be periodically flushed clean.

The collected water enters a 500 or 2000 litre capacity ferro-cement jar made using a mould (see photo). A preconstructed mould made from iron rods and polythene pipes is installed on a concrete base plate. Metal wires are extended from the base plate over the main mould to the top. Chicken mesh is then wrapped over the mould and tied securely with thin wire. A cement coating is applied over the metal structure. The jar is finished with three coatings of cement and the opening is covered with a fine nylon mesh to filter out undesired coarse matter. A tin lid is placed over the top.

A tap is fixed about 20 cm above the ground. This height allows for water to be collected in the typical 15 litre local water vessels (gagri) and avoids collection of too much water in bigger vessels as well as minimising the dead storage of water (Nakarmi et al. 2003). Trained masons can easily install the entire system. Provided all the materials and the mould are available, the entire system can be put together in about a week.

The main maintenance task is to keep the roof clean, especially after long dry periods. This is done using the gutter pipe flushing system in which the first dirty water from the roof is diverted away from the jar.

WOCAT database reference: QT NEP18
Location: Kharelthok, Sathighar, Panchkhal, Hokse and Patalekhet VDCs of the Jhikhu Khola watershed, Kabhrepalanchok district. Nepal
Technology area: 1-10 km^2
SWC measure: Structural
Land use: Settlements
Climate: Humid subtropical
Related approach: Not described
Compiled by: Madhav Dhakal, ICIMOD
Date: November 2006

General comments: Water harvesting is an ancient practice. The system used in the Jhikhu Khola watershed comes from Thailand, so the technology is often called 'Thai jar'. In Nepal, the Rural Water Supply and Sanitation Support Programme (RWSSSP) introduced it in the water deficit districts of western Nepal.

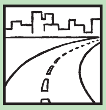
The technology was documented using the WOCAT (www.wocat.org) tool.

Classification

Water use problems

Inadequate water supply during the late winter and pre-monsoon months and sediment contamination during the wet season. The discharge from traditional water sources like dug-out ponds, springs, seepage 'holes', shallow wells, and streamlets becomes limited soon after the end of the monsoon.
Many settlements are located on ridge tops and most water sources are located below making it difficult to provide water to households through networks of pipes. Women and girls often face hardship in carrying the water uphill, especially during the monsoon when trails are slippery.

Land use

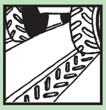


Settlement, infrastructure

Climate

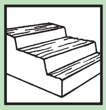
Humid subtropical

Degradation



Physical degradation: water scarcity

SWC measures



Structural: tank or jar

Technical function/impact

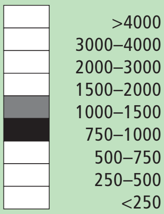
Main: - water harvesting

Secondary: - none

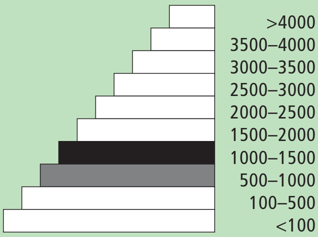
Environment

Natural environment

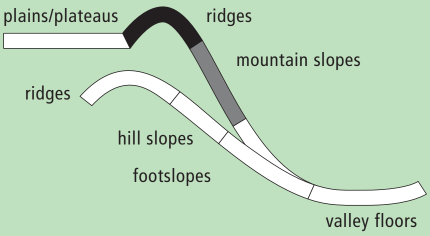
Average annual rainfall (mm)



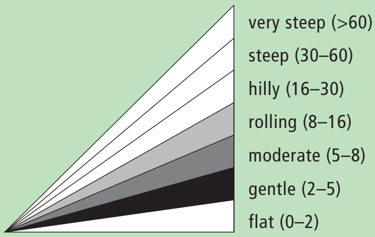
Altitude (masl)



Landform

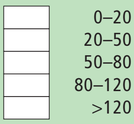


Slope (%)



Applied (large extent) Applied (medium extent) Applied (little extent)

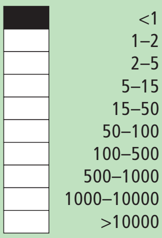
Soil depth (cm)



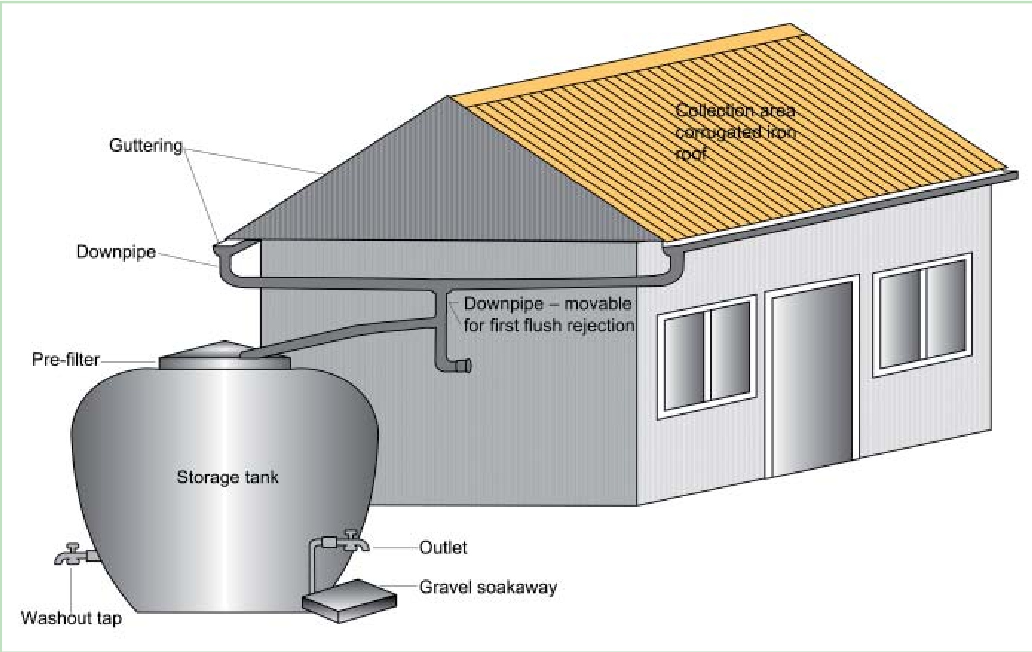
Growing season: not relevant
Soil fertility: not relevant
Soil texture: not relevant
Surface stoniness: not relevant
Topsoil organic matter: not relevant
Soil drainage: not relevant
Soil erodibility: not relevant

Human environment

Other land per household (ha)



Land use rights: individual
Land ownership: individually owned/titled
Market orientation: mostly subsistence (self-supply), mixed (subsistence and commercial: only vegetables)
Level of technical knowledge required: field staff/extension worker: high, land user: high
Number of livestock: 3.9 tropical livestock units (TLU) per household
Importance of off-farm income: In most farm households off-farm income plays at least a minor and increasingly a major role. Occasional opportunities for off-farm income present themselves in the form of daily labour wages. Some households' members receive regular salaries whilst an increasing number of Nepalis are working in India, the Middle East, Malaysia and elsewhere and sending remittance incomes home.



Technical drawing
A water harvesting system with roof catchment, connecting pipes and storage tank

Implementation activities, inputs and costs

Establishment activities

Provided all materials and moulds are available, fabrication of the entire system is completed in about a week. The work is performed with manual labour using construction tools (hacksaw, steel scissors, hammer, pliers, wrench trowel, steel pan bucket, and jug).

1) Jar construction: The first task is to construct the concrete base plate. Then the main mould is installed on the plate. Metal wires are extended from the base plate over the main mould to the top. Chicken mesh is wrapped over the mould and tied securely with thin wire. Two coats of cement are applied following which the mould is removed. A further coat of cement is applied to the inside of the jar after which the cement is cured and final checks made. A metal cap is put over the top of the jar. The jar should always be kept covered.
2) Gutter and pipe fitting: A polyethylene pipe is cut in half longitudinally leaving 15 cm uncut at one end. This forms the gutter. A piece of pipe is attached to the uncut end of the gutter vertically. A 'T' shaped pipe is attached to divert water into the jar through a reducer pipe. Another 'T' shaped pipe' is connected with a flush pipe which is kept covered with a cap, and is opened to flush contaminated water

Establishment inputs and costs per unit system (2006)

Inputs	Cost (US$)	% met by land user
Labour (15 person days: skilled and unskilled)	41.1	25%
Materials		
- Cement (4 kg)	23.6	0%
- Sand and aggregate	1.4	100%
- Chicken wire mesh and wires	20.9	0%
- Metal jar cover	5.5	0%
- Plastic sheet and mosquito screen	1.5	0%
- Paint	2.1	0%
- High density polyethylene (HDP) pipes, reducer	23.7	0%
- Nail, clamps, pipe elbow, tee connector, end cap	3.6	0%
- Nipples, brass tap, galvanized iron (GI) socket, thread seal tap	3.5	0%
TOTAL	**127**	**9%**

Maintenance/recurrent activities

The regular flushing away of dirt from the roof, especially after long dry periods and cleaning the jar once or twice a year

Maintenance/recurrent inputs and costs per unit per year (2006)

Inputs	Cost (US$)	% met by land user
Labour (7 person days)	15	100%
TOTAL	**15**	**100%**

Remarks: The mould and tools were provided by the project and can be used to install many water harvesting systems – therefore the cost of tools are not included here. Material costs fluctuate from time to time. The transport costs will vary according to the remoteness of the site. During 1999/2000, the cost of a system varied from US$80 to US$120, of which land users contributed about US$40 by providing the unskilled labour and locally available materials like sand and fine aggregates. (Calculated at an exchange rate of US$1 = NRs 73)

Assessment

Acceptance/adoption

Among 46 land user households in the case study area, 34 (74%) households accepted the technology with incentives and 12 (26%) adopted it spontaneously paying all costs themselves.
The number of households applying the technology is increasing without further incentives being provided.

Drivers for adoption

- Need for water due to very dry years

Constraints to adoption

- Not having access to the moulds and other materials for making the jars
- Technical guidance is needed and may be not available
- Costs are high

Benefits/costs according to land users

Although the initial investment is high, the users immediately get more water. The high cost of installing the system means that the short term benefits are slightly negative.

Benefits compared with costs	short-term	long-term
establishment	slightly negative	very positive
maintenance/recurrent	very positive	very positive

Impacts of the technology

Production and socioeconomic benefits

none

Production and socioeconomic disadvantages

- Loss of land by the house to accommodate the water jar

Socio-cultural benefits

+++ Strengthened community institution: together with adopters, other potential local adopters have started discussing options to overcome the scarcity of water and are searching for funds to install roofwater harvesting systems

+++ Improved knowledge of soil and water conservation and erosion through training, demonstration, and knowledge sharing

Socio-cultural disadvantages

none

Ecological benefits

++ Increased water availability in dry season

++ Better sanitation from more water available for washing leading to improved health

Ecological disadvantages

none

Other benefits

+++ Water is available near the house

+++ Greatly reduced time needed to fetch water, reducing women's workloads

++ Reduced risk of injury from carrying water along slippery and steep tracks

++ Less chance of disputes over turns to fetch water

Other disadvantages

none

Off-site benefit

++ Increased availability of water for neighbours during scarce periods

+ Reduced downstream flooding

+ Reduced downstream siltation

Off-site disadvantages

none

Concluding statements

Strengths and ➔how to sustain/improve	**Weaknesses** and ➔how to overcome
Harvested rainwater has saved almost one workday per day per family due to reduced water fetching time in this case referring to the rainy season, however water will generally be used during the dry season ➔Publicise the economic benefits of the technology through experience sharing programmes	2,000 litre capacity jars barely meet the dry season needs of a household ➔ Larger sized jars or more than one jar need to be built to meet most household's requirements
Women are responsible for fetching water and so the technology reduces their workloads ➔ Implement a larger scale programme to promote the technology	Microbiological contamination (total and faecal coliform bacteria) and levels of phosphate above the EC maximum were found in a number of the jars caused by bird droppings and dust particles from the roof ➔ Regularly clean catchment roofs and treat water before drinking by boiling or chlorinating. Rainwater has a low mineral content which can be harmful for the human body, if taken in large quantities (due to reverse osmosis process)
The jars are more durable than plastic tanks ➔Carry out regular maintenance to keep systems in good working order	This technology is not suitable for temple roofs because such roofs are usually home to large numbers of pigeons, and their excreta will contaminate rainwater that falls there ➔ Avoid badly contaminated catchments
The stored water can be kept for use in emergencies such as to prepare food for guests during busy times like rice planting and harvesting, and during festivals ➔Share experiences to extend adoption of the technology	The technology is expensive for poor households ➔ External support is needed for poor households to afford this system

Key reference(s): ICIMOD (2000) *Water Harvesting Manual*, unpublished manual prepared for PARDYP Project, ICIMOD ■ ICIMOD (2007) *Good Practices in Watershed Management, Lessons Learned in the Mid Hills of Nepal.* Kathmandu: ICIMOD ■ Nakarmi, G.; Merz, J.; Dhakal, M. (2003) 'Harvesting Roof Water for Livelihood Improvement: A Case Study of the Yarsha Khola Watershed, Eastern Nepal'. In *News Bulletin of Nepal Geological Society,* 20: 83-87 ■ Nakarmi, G.; Merz, J. (2001) *Harvesting Rain Water for Sustainable Water Supplies to Rural Households in the Yarsha Khola Watershed,* a report submitted to Kirchgemeinde Zuoz, Switzerland and ICIMOD, Kathmandu, Nepal ■ Sharma, C. (2001) *Socioeconomic Indicative Impact Assessment and Benchmark Study on Rooftop Rainwater Harvesting, Kabhrepalanchok District, Nepal,* a report submitted to ICIMOD, Kathmandu, Nepal

Contact person(s): HIMCAT/WOCAT Coordinator, International Centre for Integrated Mountain Development (ICIMOD), GPO Box 3226, Kathmandu, Nepal, himcat@icimod.org

Left: Polypit with a bamboo frame (Sanjeev Bhuchar)
Right: Vegetable seedlings in the polypit (Madhav Dhakal)

Polypit nursery

Nepal: प्लास्तिक खाल्टे नर्सरी

A simple, inexpensive and practical method for raising healthy plant seedlings

During the winter in Nepal's middle mountains, the soil temperature generally remains at 5-10^{0}C above the ambient air temperature. This principle was used to design a simple, inexpensive, and effective nursery technology for raising vegetable and horticulture seedlings in colder regions. The polypit technology allows seedlings to be raised by protecting them from the freezing temperatures that occur mostly at night.

Polypits are about 1m deep pits dug into the ground and covered with semi-transparent polythene sheets, preferably UV stabilised and supported on bamboo frames. A 30 cm high mud wall is built across the slope on the upper side of the pit. The polythene sheet is sealed on the upper side of the pit, leaving three sides unsealed but held down with stones that can be lifted to access the pit. The base and sides of the polypit are left as they are with no form of plastering.

The polythene sheet covering the pit reduces the photosynthetic photon flux (PPF) by around 30% inside the pit, still allowing sufficient sunlight to reach the plants inside. The polythene is usually removed during the day from 11 am to 4 pm to allow full sunlight to reach the plants except on rainy and very cold days. A modified version of these polypits – only 70 cm deep – were used in the Jhikhu Khola watershed to grow vegetable seedlings during the winter. The pits can be made of any reasonable size depending on the number of seedlings to be grown and the layout of the land. The Jhikhu Khola pits were about 3m long, 1.5m wide, and 0.7m deep.

Since the polypits are closed at night, the CO_2 released by the plants and soil microbes accumulates and increases to well above levels outside the pit. In a completely sealed polypit, the CO_2 concentration could reach up to 3000 ppm during the night which would be harmful for plants. Thus the polythene cover is only loosely sealed along the edges at night to regulate and maintain the concentration of CO_2 at about two to four times the ambient concentration.

The warmer protected conditions and CO_2 enrichment leads to extra growth and biomass gain for plants grown inside the pits during the winter. This technology is easy to maintain with the only maintenance costs being to repair damaged polythene sheets and frames.

WOCAT database reference: QT NEP19
Location: Panchkhal VDC of the Jhikhu Khola watershed, Kabhrepalanchok district, Nepal
Technology area: <1 km^2
SWC measure: Structural
Land use: Annual cropping
Climate: Humid subtropical
Related approach: Not described
Compiled by: Madhav Dhakal, ICIMOD
Date: November 2006

General comments: The polypit technology is useful for mountain farmers where water scarcity and low temperatures limit the potential to raise quality seedlings. The technology is being promoted in the northwest Indian state of Uttarakhand, although only a few farmers have adopted it so far. It is a very promising technology and its use should be encouraged by hill farmers and research and development organisations engaged in raising seedlings. The technology needs more participatory action research to improve it and to encourage more farmers to adopt it spontaneously.

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

Classification

Land use problems

Production is limited due to insufficient water during winter and the pre-monsoon season (from Nov-May); insufficient farm income due to small landholdings; increased inputs of chemical fertilisers.

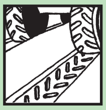
Land use

Annual crops: maize, rice and vegetables

Climate

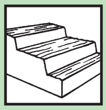
Humid subtropical

Degradation



Physical: excess harvesting of available water resources reduced

SWC measures



Structural: pit

Technical function/impact

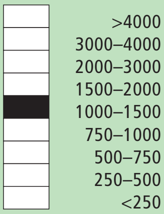
Main:
- protecting seedlings from frost
- reduction of water loss
- carbon dioxide enrichment

Secondary: - none

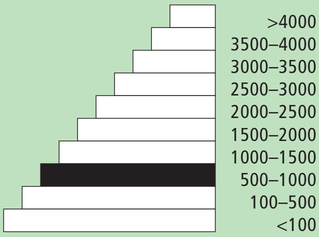
Environment

Natural environment

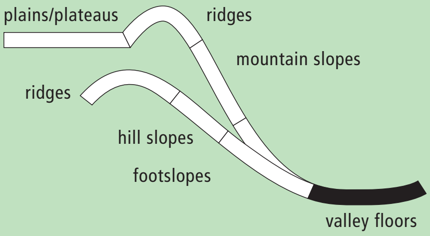
Average annual rainfall (mm)



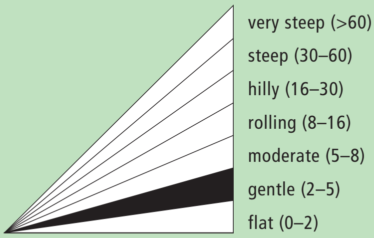
Altitude (masl)



Landform

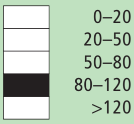


Slope (%)



Applied

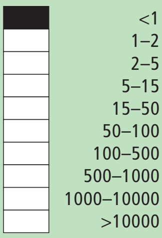
Soil depth (cm)



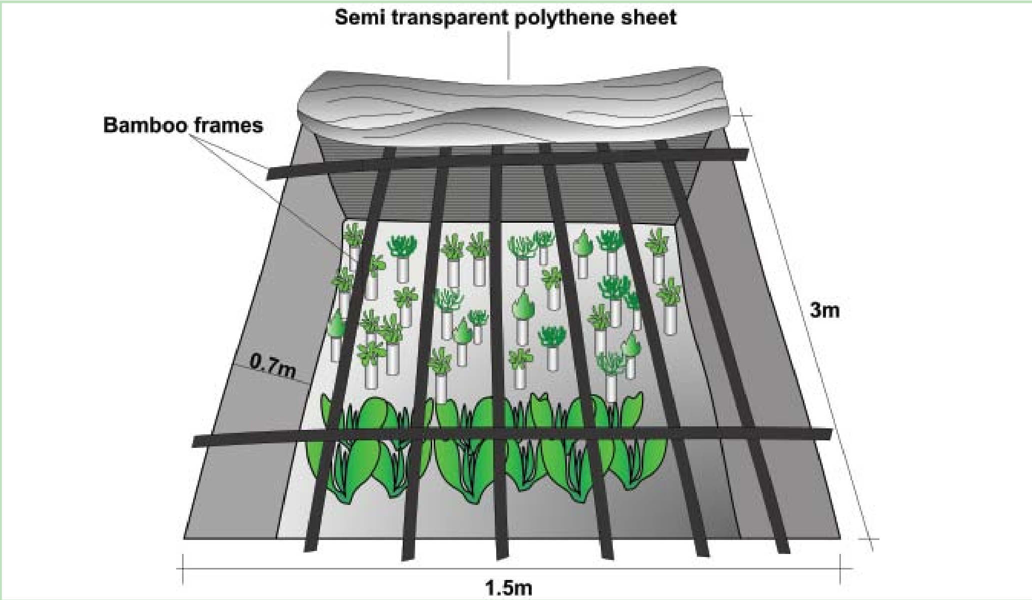
Growing season: 150 days (June to October) and 120 days (November to February)
Soil fertility: medium
Soil texture: fine to medium
Surface stoniness: no loose stones
Topsoil organic matter: medium
Soil drainage: medium
Soil erodibility: low

Human environment

Crop land per household (ha)



Land use rights: individual
Land ownership: individually owned/titled
Market orientation: mixed (subsistence and commercial)
Level of technical knowledge required: field staff/extension worker: low, land user: low
Number of livestock: not appropriate
Importance of off-farm income: in most farm households, off-farm income plays at least a minor and increasingly a major role. Occasional opportunities for off-farm income present themselves in the form of daily labour wages. Some households' members receive regular salaries, whilst an increasing number of Nepalis are working in India, the Middle East, Malaysia, and elsewhere and sending remittance incomes home.



Technical drawing
Polypit covered with semi transparent plastic sheet which is supported on a bamboo frame.

Implementation activities, inputs and costs

Establishment activities

Establishment activities are generally performed at the beginning of the winter season. All the activities are carried out manually using local agricultural tools including a wooden/iron peg spade, shovel knife, and saw. The major steps are as follows.

1. Determine the appropriate size (length, width and depth) of the pit
2. Mark the area for soil excavation
3. Excavate soil from the marked area
4. Make a mud wall (~30 cm high) from the ground, sloping on two sides
5. Make a bamboo frame of an appropriate size
6. Lay the frame over the pit with one end resting on the mud wall
7. Lay the plastic sheet over the frame
8. Seal the polythene sheet on the higher side of the mud wall and leave three sides unsealed
9. Lay the other three sides of the polythene sheet normally at ground level and weigh down with stones that can be removed to access the pit.

The base and sides of the polypit do not need any form of plastering (even with mud).

Establishment inputs and costs per unit system (2006)

Inputs	Cost (US$)	% met by land user
Labour (1 person day)	2.1	100%
Materials		
- plastic (2kg)	4	0%
- bamboo	1.3	100%
- rope	0.2	100%
TOTAL	**7.6**	**47%**

Maintenance/recurrent activities

The polythene cover is opened to acclimatise the plants to the outside environment from 11 am to 4 pm every day.
The main maintenance involves cleaning the pit and replacing the frame and polythene sheet if it gets damaged.

Maintenance/recurrent inputs and costs per unit per year (2006)

Inputs	Cost (US$)	% met by land user
Labour (1 person day)	2.1	100%
TOTAL	**2.1**	**100%**

Remarks: Exchange rate US$1 = NRs 73 in 2006

Assessment

Acceptance/adoption

This technology was tested in the Jhikhu Khola in two places for demonstration purposes. There were not enough dissemination and awareness raising activities to inform farmers of the benefits of the technology and convince them to use it.

Drivers for adoption

- Helps farmers raise better quality seedlings in less time
- The technology is useful for raising seedlings where the winters are cold
- The technology helps save water and leads to better acclimatisation of seedlings

Constraints to adoption

- Farmers have only limited knowledge of the benefits of the technology

Benefits/costs according to land users

The investment costs can be recouped within one season leading to positive results due to higher production.

Benefits compared with costs	short-term	long-term
establishment	positive	very positive
maintenance/recurrent	very positive	very positive

Impacts of the technology*

Production and socioeconomic benefits	Production and socioeconomic disadvantages
+ + + Farm income increased by 46% due to 1) the higher number of seedlings surviving in polypits (93%) compared to open nursery beds (50%) and 2) the seedlings being ready 15 days earlier compared to open nursery beds	- Hindered farm operations
Socio-cultural benefits	**Socio-cultural disadvantages**
+ + Improved knowledge of soil and water conservation and erosion: and about polypits and their advantages	none
Ecological benefits	**Ecological disadvantages**
+ + Increased soil moisture because of high relative humidity maintained inside the pits	none
Other benefit	**Other disadvantages**
+ + + Protects seedlings against frost + + Increased quality of seedlings, customers prefer to buy seedlings grown in polypits compared to those grown outside	none

* All changes in technology may have gender and equity implications and potentially affect the members of disadvantaged groups differently. This has not been assessed here but should be considered when recommending technology use.

Concluding statements

Strengths and ➔how to sustain/improve	**Weaknesses** and ➔how to overcome
Polypits are a simple, inexpensive, practical and effective technique for raising and protecting plant seedlings from severe winter temperatures. They can be called 'poor farmers greenhouses' ➔ More dissemination and awareness raising activities are needed to inform more farmers about the benefits of this technology	In completely sealed polypits, the CO_2 concentration can become so high during the night that it harms the plants ➔ Only loosely seal the sheet at night to regulate and maintain the CO_2 concentration
The high relative humidity in polypits means that watering only needs to be carried out once or twice a month in comparison to five to six times for open nursery beds, thus saving labour and water ➔ Every aspect of the technology should be highlighted through experience sharing programmes	In the demonstration, the bamboo frame to hold the sheet was too heavy making it difficult for the farmer to remove the frame and work inside ➔ Use a modified frame with a space built in to allow a person to enter the pit easily without having to remove the frame
The more conducive physical conditions and CO_2 enrichment in the pits during the winter months are reflected in the extra growth and biomass gain of plants grown inside the pits ➔As above	
The survival rate for vegetable seedlings is higher and seedlings mature about two weeks earlier than if grown outside where they take about one month to be ready, leading to additional income for farmers ➔ As above	

Key reference(s): Bhuchar, S. (2004) *Polypit: a Green-chamber for Poor Farmers,* an article prepared for PARDYP Quarterly e-Newsletter-8, ICIMOD, Kathmandu ■ Palni, L.M.S.; Bhuchar, S.; Kothyari, B.P. (1994) 'A Simple Polypit can Greatly Reduce Nursery Time of Tree Seedlings". In *Journal of HIMA-PARYAVARAN,* 6(2):10-11 ■ Vyas, P.; Bisht, M.S.; Bhuchar, S.; Sharma, S.; Palni, L.M.S. (1999) 'Polypit: An Improved Technique for Raising Nursery Plants'. In *Journal of Sustainable Forestry,* 8(1): 43-59

Contact person(s): HIMCAT/WOCAT Coordinator, International Centre for Integrated Mountain Development (ICIMOD), GPO Box 3226, Kathmandu, Nepal, himcat@icimod.org

Left: Close view of the sprinkler system head promoted by IDE (Juerg Merz)
Right: Low cost sprinkler in operation (Juerg Merz)

Low cost micro-sprinkler irrigation

Nepal: फोहरा सिंचाई

An irrigation system that delivers small-sized water droplets through a rotating head allowing longer watering time with less runoff

Micro-sprinkler irrigation is an efficient and alternative method of irrigation for high value cash crops. It has been demonstrated in the Jhikhu Khola watershed (JKW) in Nepal's middle mountains by the People and Resource Dynamics in Mountain Watersheds of the Hindu Kush-Himalayas Project (PARDYP). The NGO International Development Enterprises (IDE-Nepal) has assisted private companies to assemble and market micro-irrigation systems.

Micro sprinklers are available in a variety of configurations. They operate at a low-pressure, with water delivered at a pressure equivalent to 10-20m of head, and at a low discharge rate of 0.1-0.2 lps – equivalent to the average discharge of a 1/2 inch size public tap. A pre-assembled micro-irrigation system generally consists of 4 to 8 sprinkler heads at 4m intervals connected by half inch piping. Micro sprinklers are most suitable for closely cropped vegetables like onion and garlic.

PARDYP demonstrated, tested, and promoted the system to show land users the potential to use irrigation water very efficiently, which is important because water is in short supply for much of the year after the monsoon finishes in September. In the test area, much of the land is left fallow after the monsoon crops have been harvested as it is difficult to grow winter crops because of the lack of irrigation water.

The system is easy to install and move around. It needs a reliable source of water, such as a water harvesting tank or a tap, located about 10-20m above the field to be irrigated. A water tank can be installed at the appropriate height to give an adequate water head. The preassembled micro-sprinkler heads are inserted into the ground on a support stand and are connected to the water source via a conveyance pipe. The water passes through a filter before entering the sprinkler heads to prevent the sprinklers becoming clogged up; the system needs regular cleaning.

WOCAT database reference: QT NEP21
Location: Patalekhet VDC and Kuttal village of the Jhikhu Khola watershed, Kabhrepalanchok district, Nepal
Technology area: 0.1-1 km^2
SWC measure: Management
Land use: Annual cropping
Climate: Humid subtropical
Related approach: Not described
Compiled by: Madhav Dhakal, ICIMOD
Date: November 2006

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

Classification

Land use problems

Insufficient irrigation water during winter and the pre-monsoon season (November-May). Insufficient farm income due to small landholdings, and soil health deterioration due to increased inputs of chemical fertilisers and agrochemicals.

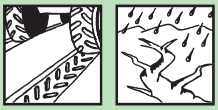
Land use

Annual crops: vegetables

Climate

Humid subtropical

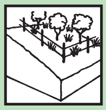
Degradation



Physical: deterioration soil moisture problem

Water erosion: topsoil washed away by water

SWC measures



Management: from traditional to improved irrigation

Technical function/impact

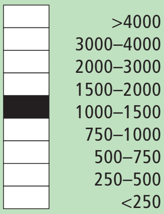
Main:
- spreading water (efficiently)
- increase/maintain water stored in soil

Secondary:
- none

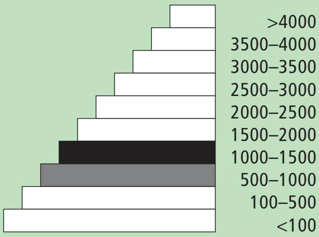
Environment

Natural environment

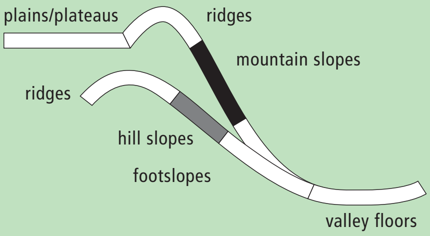
Average annual rainfall (mm)



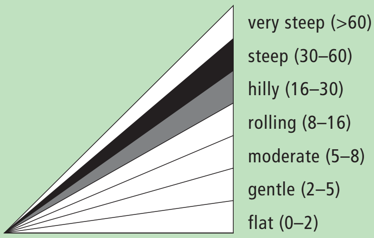
Altitude (masl)



Landform

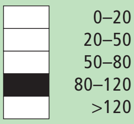


Slope (%)



Applied (large extent) Applied (medium extent)

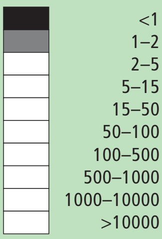
Soil depth (cm)



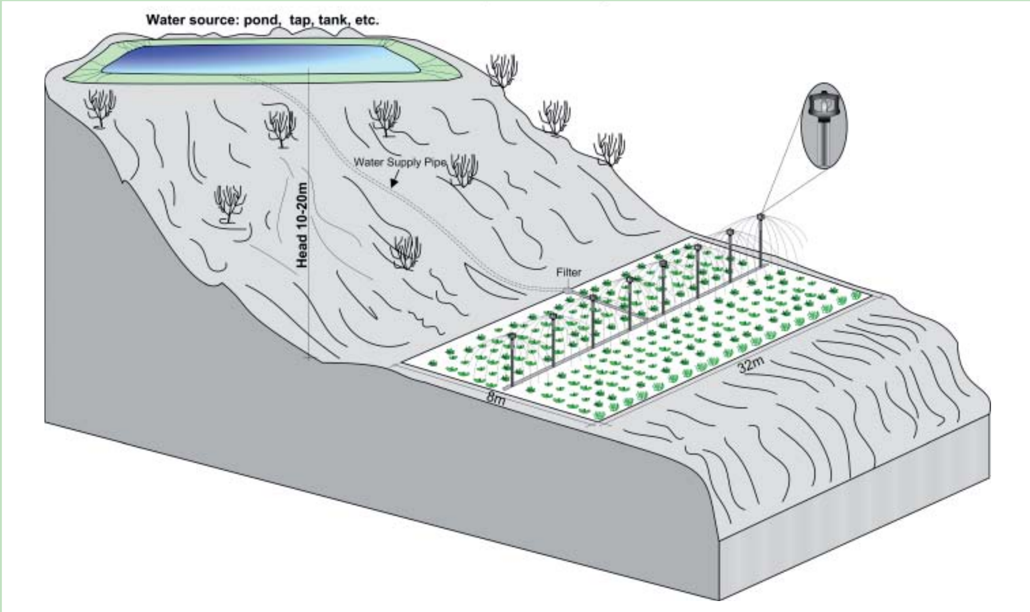
Growing season: 150 days (June to October) and 120 days (November to February)
Soil fertility: low
Soil texture: mostly fine (clay) to medium (loam)
Surface stoniness: no loose stone
Topsoil organic matter: medium
Soil drainage: medium
Soil erodibility: high

Human environment

Cropland per household (ha)



Land use rights: individual
Land ownership: individually owned/titled
Market orientation: mixed (subsistence and commercial – only vegetables)
Level of technical knowledge required: field staff/extension worker: low, land user: low
Number of livestock: not relevant
Importance of off-farm income: in most farm households, off-farm income plays at least a minor and increasingly a major role. Occasional opportunities for off-farm income present themselves in the form of daily labour wages. Some households' members receive regular salaries, whilst an increasing number of Nepalis are working in India, the Middle East, Malaysia, and elsewhere and sending remittance incomes home.



Technical drawing

Micro-sprinkler irrigation system and technical specification

Implementation activities, inputs and costs

Establishment activities

The establishment activities are performed with manual labour and using tools including a measuring tape and hammer, and are done at the beginning of the growing season. Major steps include:

1. Identify an appropriate water source (water harvesting tank, tap, pump) located about 10-20m above the irrigation site, or install a tank at the appropriate height
2. Fix the micro-sprinkler heads in the ground with their support stands
3. Connect sprinkler system with water source through conveyance pipes

Establishment inputs and costs per unit technology (2006)

Inputs	Cost (US$)	% met by land user
Labour (2 person days)	4.2	100%
Equipment		
- sprinkler heads	12.2	0%
TOTAL	**16.4**	**25%**

Maintenance/recurrent activities

1. Regular monitoring of the sprinklers' performance
2. Cleaning nozzles if clogging problem occurs

Maintenance/recurrent inputs and costs per growing season (2006)

Inputs	Cost (US$)	% met by land user
Labour (1 person day)	2.1	100%
TOTAL	**2.1**	**100%**

Remarks: The cost was calculated per unit of the technology with all necessary components (pipes, filter, fittings, and stand) and 4 micro-sprinkler heads, which is sufficient to irrigate an area of 250m^2. Exchange rate US$1 = NRs 73 in 2006

Assessment

Acceptance/adoption

Fifteen households accepted the technology with a 100% subsidy of the cost of the system. About 500 households in Patalekhet VDC have adopted the technology without subsidies by buying and using the sprinklers.

Drivers for adoption

- Efficient use of water
- Simple and cost-effective
- Leads to better crop production

Constraints to adoption

- Increased maintenance due to extra supervision, checking and cleaning of sprinkler system
- Many farmers do not have enough knowledge about the technology

Benefits/costs according to land users

The table shows the perceptions of land users who accepted the technology with incentives from the PARDYP project. The short-term benefits are positive even if users have to buy the system themselves.

Benefits compared with costs	short-term	long-term
establishment	slightly positive	positive
maintenance/recurrent	very positive	very positive

Impacts of the technology*

Production and socioeconomic benefits		Production and socioeconomic disadvantages
+ +	Increased farm income due to increased vegetable production	none

Socio-cultural benefits		Socio-cultural disadvantages
+ + +	Improved knowledge of soil and water conservation and erosion: user group started sharing their knowledge on micro-irrigation	none
+ +	Community institution strengthening: an informal network of sprinkler users formed	

Ecological benefits		Ecological disadvantages
+ + +	Increased soil moisture due to precise delivery of water (0.1 - 0.2 lps)	none
+	Reduced soil loss due to uniform application of water to crops grown on sloping land	

Other benefit		Other disadvantages
+ +	Made the irrigation of multiple vegetables possible on a rotational basis as users can shift the system around to irrigate more than one plot	none

* All changes in technology may have gender and equity implications and potentially affect the members of disadvantaged groups differently. This has not been assessed here but should be considered when recommending technology use.

Concluding statements

Strengths and ➔how to sustain/improve	**Weaknesses** and ➔how to overcome
Extremely useful for closely spaced, leafy vegetables such as onions, garlic and spinach grown in small areas ➔Suitable for row crops like bitter gourd during their initial stage of growth; and also good for a wide range of row crops (tree crops and vegetables) that require low-flow irrigation	Sometimes sprinklers stop functioning as they do not rotate and can become disconnected from the pipe ➔Regular checking and cleaning
Most appropriate for sloping land ➔Can be used on level land if tank placed at appropriate height	Are susceptible to being stolen as they can be easily dismantled ➔ Regular site visits by the farmer
Easy to transport, and possible to use for different crops in rotation ➔ Position of the sprinkler head should be changed to acquire 100% overlap of watered areas	
Allows uniform distribution of water and longer watering time with less runoff; therefore reduces soil loss from sloping land and increases soil moisture status ➔The technology should be shared with a wider audience	
Sprinkler showers drive away insects ➔ As above	
Is equally useful to irrigate fallow land to increase soil moisture ➔ As above	

Key reference(s): ICIMOD (2007) *Good Practices in Watershed Management, Lessons Learned in the Mid Hills of Nepal.* Kathmandu: ICIMOD

Contact person(s): HIMCAT/WOCAT Coordinator, International Centre for Integrated Mountain Development (ICIMOD), GPO Box 3226, Kathmandu, Nepal, himcat@icimod.org

Left: A plastic-lined dug out pond holding household wastewater and runoff from the courtyard (K.M. Sthapit)
Right: The water from these ponds can be used to run micro-irrigation systems (drip as in picture and sprinkler) (PARDYP)

Plastic-lined conservation pond to store irrigation water

Nepal: प्लास्टिक बिछ्याइएको संरक्षण पोखरी

A plastic-lined dugout pond to store runoff and household wastewater for irrigation purposes during dry periods

Water harvesting technology is very useful in areas where there is limited rainfall for long periods of the year. These dry periods severely limit the growing of crops across Nepal's middle mountains especially on steep slopes where conventional irrigation can be difficult to arrange. Plastic-lined conservation ponds store water for irrigation more efficiently than the traditional earthen ponds which lose much water to seepage.

The ponds are dug out and the earthen walls lined with high density polyethylene (HDPE) sheet or SILPAULIN (multi-layered, cross laminated, UV stabilised) heavy duty plastic sheeting. The size of the pond will vary depending on the area available and the soil characteristics. The PARDYP project tested and demonstrated plastic-lined ponds with a capacity of 8,000-10,000 litres. These ponds were about 3m long, 2m wide and 1.5m deep and were located at shady sites to minimise evaporation losses.

The conservation ponds tested and demonstrated by the PARDYP project were used for irrigating high value off-season horticultural crops (vegetables, fruit, and spices). These crops were irrigated with drip irrigation and micro sprinklers (see sheets QT NEP6 and QT NEP21). The ponds were fed from rainwater, upland springs and taps, and household wastewater.

The ponds were established during the dry season in three days. They were prepared by selecting a suitable site with a sufficient catchment; mapping out the area and depth of the pond; digging out the soil; removing protruding stones and roots; and compacting and smoothing the sides and bottom of the pond. Then the sides and bottom of the pond were lined with sieved soil followed by plastic sheet, which was anchored by stones and soil.

The main maintenance activity is to prevent livestock and people from entering the pond to avoid damaging the sheet. The pond should not be allowed to dry up as this would let rats damage the sheet. The sediment that accumulates in the pond should be removed once a year carefully by hand only as the use of agricultural tools could puncture the sheet.

WOCAT database reference: QT NEP22
Location: Lamdihi, Patalekhet, Chiuribot villages of the Jhikhu Khola watershed, Kabhrepalanchok district, Nepal
Technology area: < 0.1 km^2
SWC measure: Structural
Land use: Annual cropping
Climate: Humid subtropical
Related approach: Not described
Compiled by: Madhav Dhakal, ICIMOD
Date: November 2006

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

Classification

Land/water use problems

- Small landholdings which are mostly rainfed for cropping.
- Low soil fertility status and high susceptibility to erosion.
- Limited supplies of irrigation water and poor irrigation infrastructure.

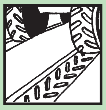
Land use

Annual crops: vegetables

Climate

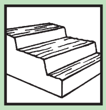
Humid subtropical

Degradation



Physical: excess harvesting of available water resources reduced

SWC measures



Management: from traditional to improved irrigation

Technical function/impact

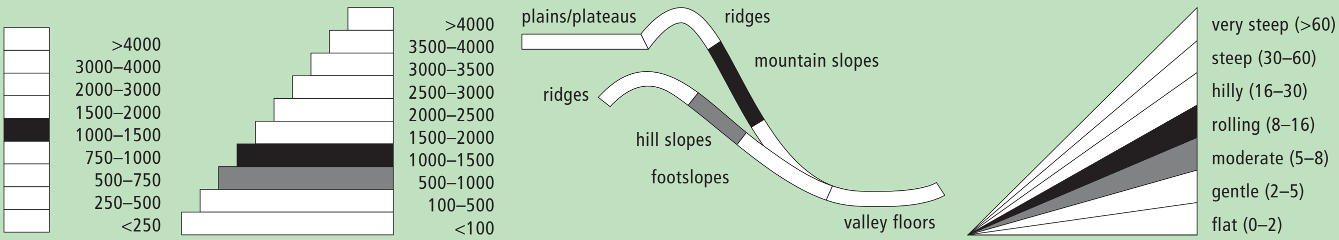
Main: - water harvesting

Secondary: - control of dispersed runoff (retain/trap)

Environment

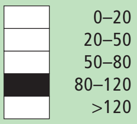
Natural environment

Average annual rainfall (mm) **Altitude (masl)** **Landform** **Slope (%)**



Applied (large extent) Applied (medium extent)

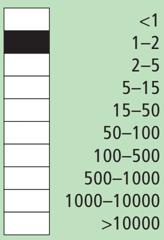
Soil depth (cm)



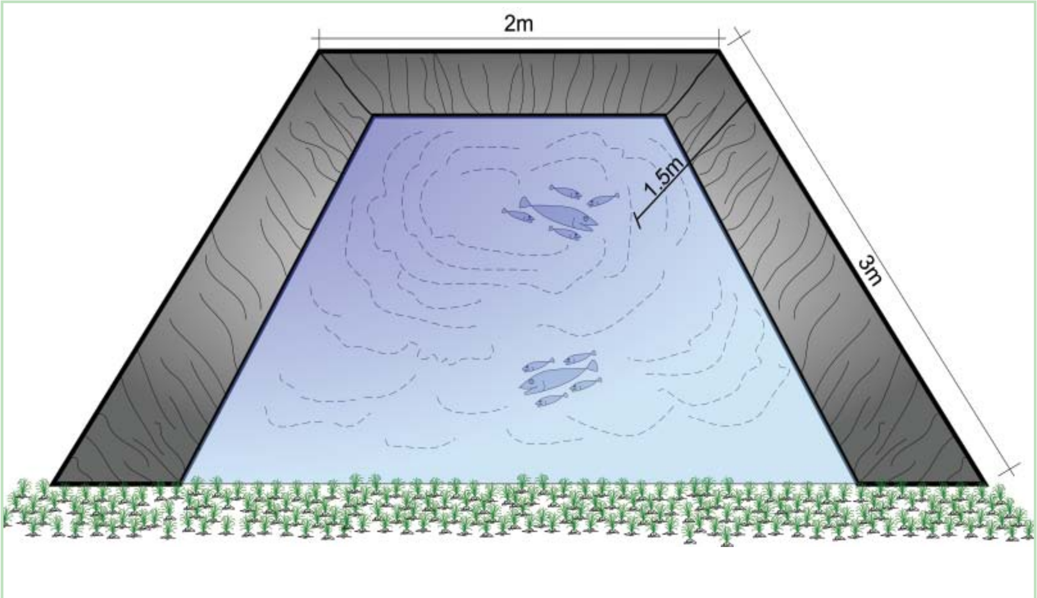
Growing season: 150 days (June to October) and 120 days (November to February)
Soil fertility: medium
Soil texture: mostly medium (loam) to fine (clay)
Surface stoniness: some loose stone
Topsoil organic matter: not appropriate
Soil drainage: good
Soil erodibility: good

Human environment

Cropland per household (ha)



Land use rights: individual
Land ownership: individually owned/titled
Market orientation: mixed (subsistence and commercial-only vegetables)
Level of technical knowledge required: field staff/extension worker: moderate, land user: moderate
Number of livestock: not appropriate
Importance of off-farm income: in most farm households, off-farm income plays at least a minor and increasingly a major role. Occasional opportunities for off-farm income present themselves in the form of daily labour wages. Some households' members receive regular salaries, whilst an increasing number of Nepalis are working in India, the Middle East, Malaysia, and elsewhere and sending remittance incomes home.



Technical drawing
A plastic-lined conservation pond

Implementation activities, inputs and costs

Establishment activities

The establishment activities are performed with manual labour using local construction tools including a measuring tape, spade, shovel, knife, hoe, hammer, trowel, and pan. Establishment activities are done during the dry months and can be completed within three days. The major steps are as follow.

1. Select a preferably flat site with a sufficient catchment area
2. Measure the area to be irrigated and estimate the size of the pond
3. Measure and mark out the pond
4. Dig out the soil to the pre-determined depth
5. Remove protruding stones and roots
6. Compact and smooth the sides and bottom of the pond
7. Line the sides and bottom of the pond with sieved soil (preferably a clay and cow dung mixture) to make a smooth surface
8. Lay out the plastic sheets without any folds over the pond with overlapping of about 50 cm at any joints. Fold overlapped sections to reduce leakage
9. Overlay thick fine soil on the plastic sheet
10. Anchor the edges of the sheet at the rim of the pond with stones and soil.

Establishment inputs and costs per unit technology (2006)

Inputs	Cost (US$)	% met by land user
Labour (3 person days)	6.3	100%
Material		
- Plastic (6 kg)	29.2	0%
TOTAL	**35.5**	**18%**

Maintenance/recurrent activities

1. Prevent livestock and humans from entering the pond
2. Ensure that the pond is not allowed to dry out completely as this could allow rats to damage the plastic sheet
3. Removing accumulated sediment once a year carefully by hand (using agricultural tools may puncture the sheet)

Maintenance/recurrent inputs and costs per system per year (2006)

Inputs	Cost (US$)	% met by land user
Labour (3 person days)	6.3	100%
TOTAL	**6.3**	**100%**

Remarks: The costs given above are for a pond with a 9,000 litre capacity. Exchange rate US$1 = NRs 73 in 2006

Assessment

Acceptance/adoption

Five families accepted the technology with incentives. No known spontaneous adoption of the technology because of the expense of the plastic sheet and it not being locally available

Drivers for adoption

- Addresses water scarcity problem during dry months
- Reduces workload for collecting water
- Enables farmers to grow cash crops

Constraints to adoption

- The plastic sheet is not available locally
- The plastic sheet is expensive

Benefits/costs according to land users

Perception of land users who accepted the technology by getting incentives from the PARDYP project. If incentives are not available the short-term costs and benefits would be equal.

Benefits compared with costs	short-term	long-term
establishment	positive	very positive
maintenance/recurrent	very positive	very positive

Impacts of the technology*

Production and socioeconomic benefits	Production and socioeconomic disadvantages
++ Increased farm income due to availability of more water for irrigation	- Loss of land - Hindered farm operations
Socio-cultural benefits	**Socio-cultural disadvantages**
+++ Improved knowledge of soil and water conservation and erosion as farmers discussed and shared their experiences ++ Strengthened community institution due to informal network of farmers with ponds	none
Ecological benefits	**Ecological disadvantages**
+++ Increased soil moisture + Improved soil cover as fallow land is turned into cropped land	none
Off-site benefit	**Off-site disadvantages**
+ Reduced downstream flooding due to trapped runoff	none

* All changes in technology may have gender and equity implications and potentially affect the members of disadvantaged groups differently. This has not been assessed here but should be considered when recommending technology use.

Concluding statements

Strengths and ➔how to sustain/improve	**Weaknesses** and ➔how to overcome
Good income from sales of vegetables in the dry season can be achieved even from a small piece of land ➔ Advantages of the technology should be more widely shared	SILPAULIN (multi-layered, cross laminated, UV stabilized) heavy duty plastic is not available in local markets and is expensive for poor farmers ➔ Make it available in the local market at a subsidised cost for poor farmers
These ponds are fed with rainwater and household wastewater and from springs and taps. The ponded water was mainly used for micro irrigation including drip irrigation and micro-sprinklers ➔ Promote the use of other water conserving techniques like mulching when using the harvested water	The ponds attract insects, mainly mosquitoes, that cause disease; and the ponds are unsafe for small children ➔ Regularly clean the pond and fence them in
Reduced the dependence on large scale water supply schemes ➔ Harvest all possible sources of water	
No seepage loss observed five years after building the ponds meaning that the plastic lasts at least five years ➔ Continue trials	

Key reference(s): ICIMOD (2007) *Good Practices in Watershed Management, Lessons Learned in the Mid Hills of Nepal.* Kathmandu: ICIMOD ■ SCWMC (2004) *Soil Conservation and Watershed Management Measures and Low Cost Techniques.* Kathmandu: Government of Nepal, Soil Conservation and Watershed Management Component - Department of Soil Conservation and Watershed Management ■ Shafiq, M.; Ikram, M.Z.; Nasir, A. (1995) *Water Harvesting Techniques for Sustainable Agriculture in Dry and Cold Mountain Areas.* Paper presented at the Workshop on Sustainable Agriculture in Dry and Cold Mountain Areas, Pakistan Agricultural Research Council, 25-27 September1995, Queta, Pakistan

Contact person(s): HIMCAT/WOCAT Coordinator, International Centre for Integrated Mountain Development (ICIMOD), GPO Box 3226, Kathmandu, Nepal, himcat@icimod.org

Left: Different grasses on terrace risers (Juerg Merz)
Centre: Broom grass growing in the forest (Juerg Merz)
Right: Napier grass growing on a terrace riser (Juerg Merz)

Cultivation of fodder and grasses

Nepal: डालेघाँस तथा भूईघाँस प्रवर्द्धन

Cultivation of fodder crops on marginal lands and terrace risers

Fodder plays a major role in the crop-livestock-manure-soil nutrient cycle on farms in the middle mountains of the Himalayas. Livestock convert fodder shrubs and grasses from the forest, crop residues, and other fodder into manure through digestion. However, in the middle hills of Nepal the lack of availability of good quality fodder often limits not only, the productivity of livestock, but also reduces the nitrogen content of animal dung if, for example, only cereal crop residues, are fed to the animals.

In earlier times, livestock were left to graze in the forests and on community lands. The animals sought out their own food and were only assembled for milking and to protect them from wild animals. With the introduction of stall-feeding, the demand for fodder has increased greatly with a subsequent large increase in women's workload as it is they who are responsible for collecting the fodder.

Most fodder is collected in forest areas, and most livestock manure is applied to arable land, in particular to rainfed fields. This results in a net transfer of nutrients from forest areas to arable lands. It is estimated that, in this way, about 3 to 7 ha of forest land is needed to maintain 1 ha of arable land without degrading the state of the forest. In addition to reducing the availability of forest resources, the widespread closure of community forests has diminished access to fodder during certain times of the year. All this is putting serious pressure on the remaining unprotected forest resources.

Marginal lands and terrace risers offer an opportunity to reduce this pressure. The planting of grasses and shrubs suitable for fodder on these areas not only increases fodder availability but also reduces erosion and landslides that originate in these areas. If leguminous fodder species are planted, they increase soil fertility by increasing the nitrogen content in soils.

The Sustainable Soil Management Programme (SSMP) implements its projects in several midhills districts of Nepal
(dark green: previous working districts;
light green: districts in 2007)

WOCAT database reference: QT NEP23
Location: Nepal midhills
SWC measure: Vegetative
Land use: Annual cropping on rainfed agricultural land
Climate: Humid subtropical
Related approach: Farmer-to-farmer diffusion (QA NEP1), Farmer-led experimentation (QA NEP3), Farmer field school on integrated plant nutrient systems (QA NEP4)
Compiled by: SSMP
Date: January 2007

The Sustainable Soil Management Programme is implemented by Helvetas Nepal and Intercooperation in collaboration with the Government of Nepal and civil society actors. It is financed by the Swiss Agency for Development and Cooperation. The technology was documented using the WOCAT (www.wocat.org) tool.

Classification

Land use problems

Increasing livestock numbers causing the degradation of unprotected forest areas. The closure of large areas of community managed forests to grazing and fodder collection is putting more pressure on unprotected forest areas and increasing the demand for alternative sources of fodder and better quality fodder.

Land use

Annual crops: maize-wheat, potato, mustard, different types of vegetables

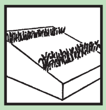
Climate

Humid subtropical

Degradation

Chemical degradation: soil fertility decline, soil nutrient mining

SWC measures



Vegetative: fodder and grasses `

Technical function/impact

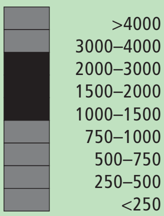
Main:
- increased availability of fodder
- improved manure quality
- increased quantity of manure
- increased soil fertility

Secondary:
- nitrogen fixation (if leguminous species are planted)

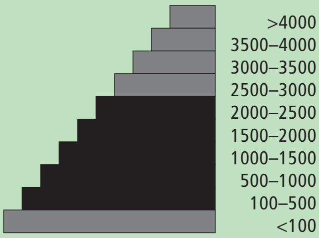
Environment

Natural environment

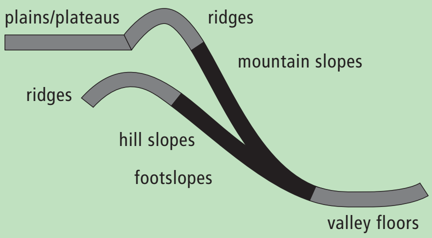
Average annual rainfall (mm)



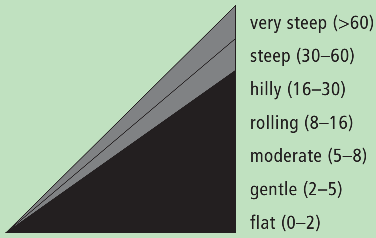
Altitude (masl)



Landform



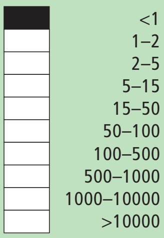
Slope (%)



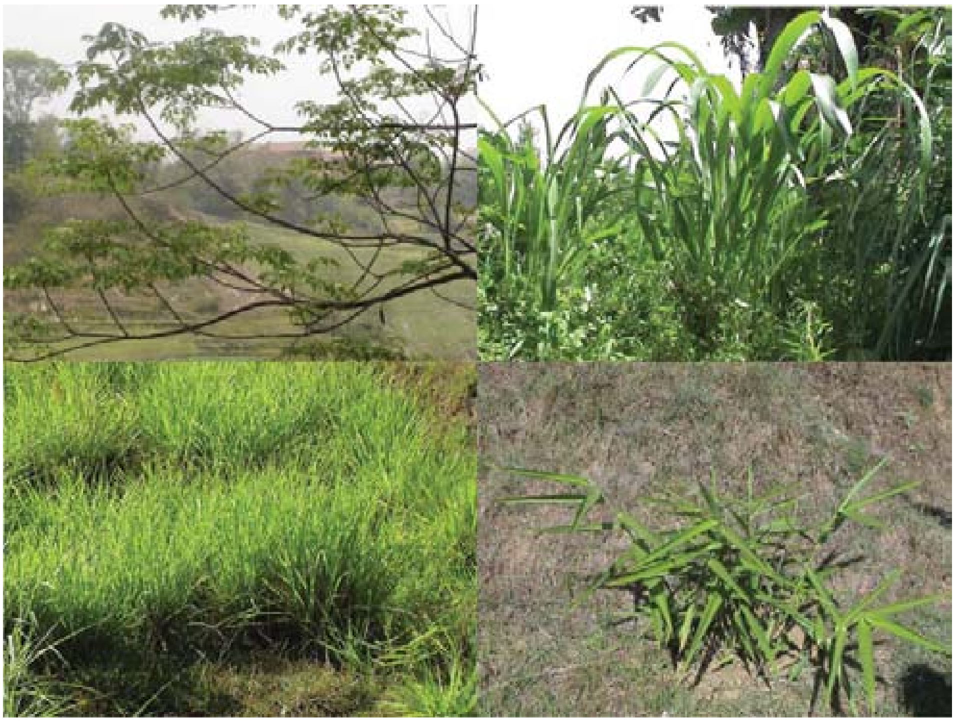
Applied Potential

Human environment

Cultivated land per household (ha)



Land use rights: individual, leased (sharecropping between owner and tenant)
Land ownership: individually owned, titled and not titled
Market orientation: subsistence, commercial, and mixed (subsistence/commercial)
Level of technical knowledge required: low
Number of livestock: poor households usually have some goats and one cow or buffalo, weathier households often own several cattle, buffaloes, and a pair of oxen for ploughing.
Importance of off-farm income: in most farm households, off-farm income plays at least a minor and increasingly a major role. Occasional opportunities for off-farm income present themselves in the form of daily labour wages. Some households' members receive regular salaries, whilst an increasing number of Nepalis are working in India, the Middle East, Malaysia, and elsewhere and sending remittance incomes home.



Fodder and grass species promoted by SSMP

Tree species:
badahar *(Artocarpus lakoocha)*
dudhilo *(Ficus nemoralis)*
nemaro *(Ficus roxburghi)*
tank *(Bauhinia purpurea)*
bakaino *(Melia azedarach)*
neem *(Melia azadirachta)*
raikhanayo *(Ficus semicordata)*
mulberry *(Morus spp.)*
ipil ipil *(Leucaena diversifolia)*
gajuma *(Gauzuma ulmitolica)*

Shrub species:
bhatamase *(Flemingia congesta)*

Grass species:
stylo *(Stylosanthes spp.)*
dinanath *(Penisetum spp.)*
molasses, Napier grass NB21 *(Penisetum purpureaum)*

Implementation activities, inputs and costs

Establishment activities

1. Establish nursery for saplings/seedlings, and procure seed of appropriate species
2. Transplant at appropriate time on wasteland areas around houses and terrace risers as given in the Agroforestry Training Manual (NAF, SSMP 2002)

Duration of establishment: depends on species

Establishment inputs and costs per ropani

Inputs	Cost (US$)[1]	% met by land user
Seeds or saplings/seedlings	depends on species	100%
Labour (~2-3 days)	4-6	0%
TOTAL	**< 10**	**100%**

[1] Exchange rate US$ 1 = NRs 67 in January 2007

Maintenance/recurrent activities

1. Depending on species, newly established trees and shrubs need to be pruned, pollarded, or coppiced; grasses need no further agronomic practices
2. Replace dead plants and ones that failed to establish

Maintenance/recurrent inputs and costs per ha per year

Inputs	Cost (US$)[1]	% met by land user
Labour (~ 2–3 days)	4-6	100%
TOTAL	**4-6**	**100%**

[1] Exchange rate US$ 1 = NRs 67 in January 2007

Assessment

Acceptance/adoption

The widespread need for more and improved fodder means that 80% of the farmers exposed to this technology by SSMP adopted it. For farmers who participated in SSMP's activities, with or without direct reference to fodder promotion, about 30% have planted a variety of new fodder species on their private land. About 10% of local farmers not involved in SSMP have adopted the technology. Some of the farmers say that the health of their livestock improved and milk production increased after they were fed with the improved fodder.

Drivers for adoption

- Inexpensive technology
- Improved fodder availability
- Improved livestock health and productivity
- Reduced workload for women

Constraints to adoption

- Availability of seeds/seedlings/slips

Benefits/costs according to land users

Benefits compared with costs	short-term	long-term
establishment	positive	positive
maintenance/recurrent	positive	positive

Impacts of the technology*

Production and socioeconomic benefits	Production and socioeconomic disadvantages
+ + + Increased fodder availability	- - Reduced crop production due to shading effect
+ + + Improved fodder quality	
+ + + Increased milk production	
+ Increased manure availability	
+ Better livestock health	
+ Some of the new species provide inputs for organic pest management	
Socio-cultural benefits	**Socio-cultural disadvantages**
+ + Reduced workload, mainly for women	none
Ecological benefits	**Ecological disadvantages**
+ + + Reduced need for free grazing	- In places, increased incidence of rodents
+ + + Reduced erosion from terrace bunds and marginal lands	- In places, increased incidence of snakes
Off-site benefit	**Off-site disadvantages**
+ + + Reduced pressure on forest resources	none

* All changes in technology may have gender and equity implications and potentially affect the members of disadvantaged groups differently. This has not been assessed here but should be considered when recommending technology use.

Concluding statements

Strengths and ➔how to sustain/improve	**Weaknesses** and ➔how to overcome
Improves fodder quantity and quality with a positive impact on livestock health and productivity	In places fodder grasses and shrubs have increased the incidence of rodents and snakes
Increased fodder availability near the house reduces the workload of women to collect fodder and grass for livestock	Shading effect on field crops ➔ select appropriate species; pruning and pollarding to manage height of the plants
Feeding of improved fodder and grasses improves quality of farmyard manure and thereby reduces need for mineral fertiliser	Host of insect pests
Different species provide source of mulching and staking material	Some species (e.g. bamboo, eucalyptus) have alleopathic effects that inhibit the growth of crop and other plants ➔ only plant such species on wastelands or along river banks

Key reference(s): NAF; SSMP (2002) *Agroforestry Training Manual* (in Nepali). Kathmandu: Nepal Agroforestry Foundation and Sustainable Soil Management Programme

Contact person(s): Director, Soil Management Directorate, Department of Agriculture, Harihar Bhawan, Lalitpur, +977 1 5520314 or
Team Leader, Sustainable Soil Management Programme (SSMP), GPO Box 688, Kathmandu/Nepal, +977 1 5543591 ssmp@helvetas.org.np

Left: Urine application with drip irrigation technology for bitter gourd (Juerg Merz)
Right: Filtration of urine through a cloth (Juerg Merz)

Urine application through drip irrigation for bitter gourd production

Nepal: करेला खेतीमा थोपा सिंचाइको साथमा पशुमूत्रको प्रयोग

Application of cattle urine through drip irrigation technology to provide constant flow of fertiliser to bitter gourd

Bitter gourd vegetables fetch a high price in the off-season and respond well if grown with drip irrigation. This crop is planted in December/January and harvested from May through to July/August. The growing period mainly falls in the driest period of the year and therefore requires irrigation.

In addition to water, the plants need fertiliser to ensure healthy growth and good production. Nitrogen is the most important macronutrient for plants and high crop productivity can only be achieved if sufficient nitrogen is available. Nitrogen is also the most limiting nutrient in most areas of Nepal's midhills. Traditionally farmers applied farmyard manure; but in many places this is being supplemented or entirely replaced by inorganic fertiliser, mainly urea. However, fertiliser prices have increased substantially in recent years and this type of fertiliser is often not available in sufficient quantities in areas away from the roadheads. At the same time cultivation practices are intensifying with greater cropping intensities and more nutrient demanding crops as local varieties are replaced by hybrids and new crops are introduced. This can easily lead to nutrient mining and soil fertility decline unless there is an equivalent increase in inorganic or mineral fertilisation.

Cattle urine is a viable alternative to mineral fertiliser; it is nitrogen rich. The urine is collected in improved cattle sheds (fact sheet on urine collection QT NEP1). For constant fertiliser application and to reduce the water requirement, the collected urine can be added to the irrigation water in the drip irrigation tanks (fertigation). Farmers who have tried this say it has increased the yield of bitter gourd and other cash crops, in some cases by as much as 100%. Other crops that can be grown using drip irrigation with a water-urine mixture are cauliflower, cucumber, and other types of gourd.

The Sustainable Soil Management Programme (SSMP) implements its projects in several midhills districts of Nepal
(dark green: previous working districts;
light green: districts in 2007)

Wocat database reference: QT NEP24
Farmer's name: Iman Singh Basnet, Latikoili VDC, Ward 1
Location: Surkhet district, western midhills of Nepal
SWC measure: Management
Land use: Annual cropping on rainfed agricultural land
Climate: Humid subtropical
Related approach: Farmer-to-farmer diffusion (QA NEP1); Farmer-led experimentation (QA NEP3); Farmer field schools on integrated plant nutrient systems (QA NEP4)
Compiled by: SSMP
Date: 18 April 2007

The Sustainable Soil Management Programme is implemented by Helvetas Nepal and Intercooperation in collaboration with the Government of Nepal and civil society actors. It is financed by the Swiss Agency for Development and Cooperation. The technology was documented using the WOCAT (www.wocat.org) tool.

Classification

Land use problems

Intensifying cultivation practices with either 1) inadequate application of fertilisers leading to a decline in soil fertility and the mining of soil nutrients or 2) application of too much fertiliser causing environmental problems through excessive leaching, and losses of fertiliser in surface runoff and consequent eutrophication or nitrification of streams, ponds, or groundwater. Also, irrigation water is in short supply during 6 to 8 months of the year. Fertigation allows about 20 to 30% of the irrigation water to be replaced by urine.

Land use

Annual crops: maize-wheat, potato, mustard, different types of vegetables

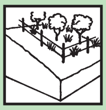
Climate

Humid subtropical

Degradation

Chemical degradation: soil fertility decline, soil nutrient mining

SWC measures



Management: application of urine rather than urea; drip irrigation

Technical function/impact

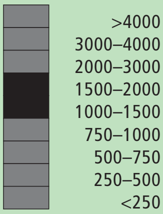
Main:
- supplementary irrigation
- constant and slow supply of nutrients
- increase in soil fertility
- increase in soil productivity

Secondary:
- pest control

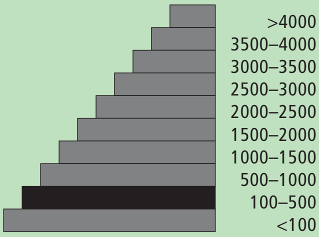
Environment

Natural environment

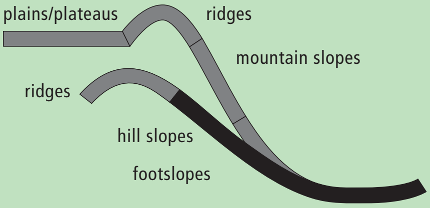
Average annual rainfall (mm)



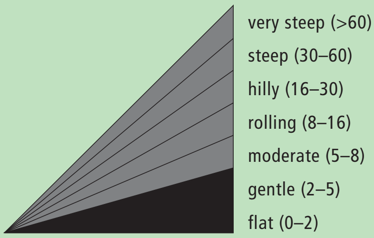
Altitude (masl)



Landform



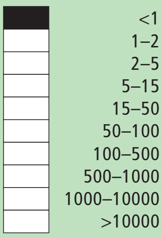
Slope (%)



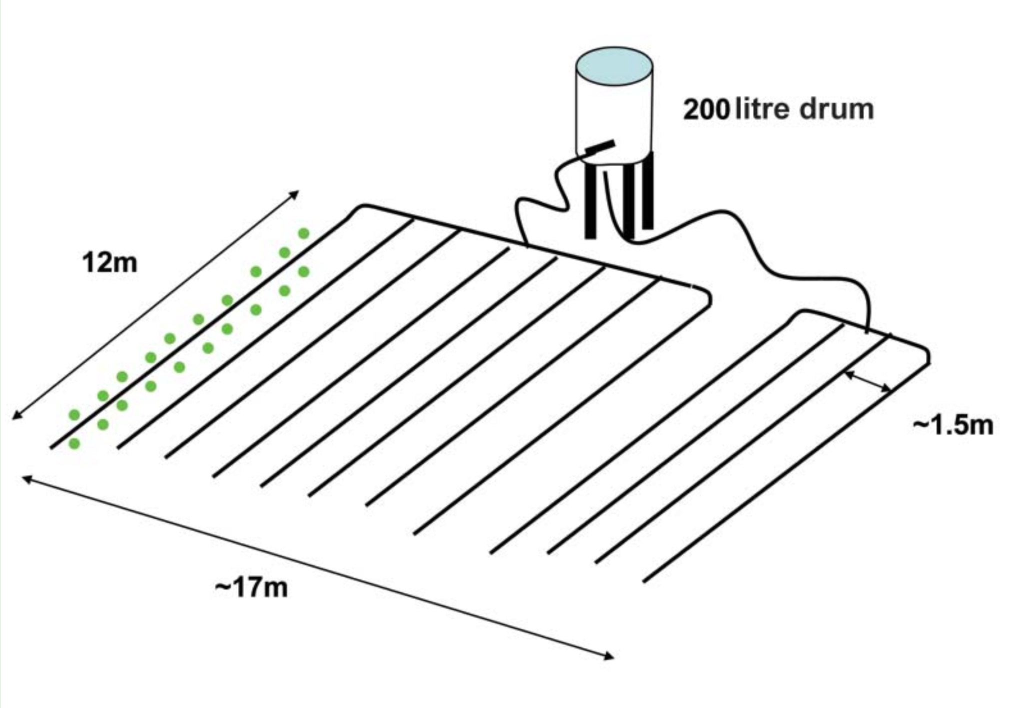
Applied   Potential

Human environment

Cultivated land per household (ha)



Land use rights: individual, leased (sharecropping between owner and tenant)
Land ownership: individually owned, titled and not titled
Market orientation: subsistence, commercial and mixed (subsistence/commercial)
Level of technical knowledge required: low
Number of livestock: poor households usually have some goats and a cow or buffalo; wealthier households often own several cattle, buffaloes and a pair of oxen for ploughing.
Importance of off-farm income: in most farm households, off-farm income plays at least a minor and increasingly a major role. Occasional opportunities for off-farm income present themselves in the form of daily labour wages. Some households' members receive regular salaries, whilst an increasing number of Nepalis are working in India, the Middle East, Malaysia, and elsewhere and sending remittance incomes home.



Technical drawing

The following setup was used in Iman Singh Basnet's field:

- two drip irrigation sets: one set with 8 lines, one with 4 lines
- a 200 l plastic drum
- 20 bitter gourd plants per line with 1.5m spacing between lines
- approximate area covered: 200m^2

Note that the drum was not delivered with the drip irrigation set. Mr Basnet uses the same drum for irrigating other crops where drip irrigation is not feasible, in which case he connects a pipe with a rose to the drum.

Implementation activities, inputs and costs

Establishment activities

1. Collect urine (see WOCAT fact sheet 'Improved cattle shed for improved urine collection – QT NEP1)
2. Grow bitter gourd seedlings
3. Set up drip irrigation set and prepare field
4. Transplant seedlings
5. Prepare and place stakes

Duration of establishment: about 2 days spread over 1 month

Establishment inputs and costs (average)

Inputs	Cost (US$)[1)]	% met by land user
Labour (2 days)	4	100%
Drip irrigation set	36	100%
Drum (200 l)	4	100%
Stakes	6	
TOTAL	**50**	**100%**

[1)] Exchange rate US$1 = NRs 67 in January 2007

Maintenance/recurrent activities

1. Clear drip holes
2. Double filter the urine – once when taking out of the collection tank, and again when pouring into the drip irrigation tank
3. Irrigate every alternate day with 160 l water and 40 l urine.
4. Fix shoots to the stakes
5. Raise ridges for better irrigation efficiency
6. Harvest the crop

Maintenance/recurrent inputs and costs per crop

Inputs	Cost (US$)[1)]	% met by land user
Labour (1.5 hr/day every alternate day ➔ 15 days))	30	100%
TOTAL	**30**	**100%**

[1)] Exchange rate US$1 = NRs 67 in January 2007

Assessment

Acceptance/adoption

Drip irrigation was introduced to Latikoili VDC in particular and other VDCs of Surkhet district, western Nepal in recent years by Smallholder Irrigation and Market Initiatives (SIMI) Nepal, a project supported by USAID. A number of farmers have taken up drip irrigation sets for commercial vegetable production. Iman Singh Basnet bought his set himself and started applying urine through drip irrigation in 2005. In 2006/07 he grew his second crop in this way. Other local farmers started to use the same technology in 2006. Their experiences still need to be documented.

Drivers for adoption

- local resource
- reduced need for costly mineral fertilisers
- reduced water requirement
- positive impact on crop productivity
- pest control

Constraints to adoption

- inadequate amount of urine
- increased labour requirement due to increased blockage of holes in the drip irrigation system
- high initial establishment cost
- exact quantity of nitrogen cannot be measured
- needs correct dilution with irrigation water

Benefits/costs according to land users

The high cost of mineral fertiliser and the high price that bitter gourd fetches means that the establishment costs are soon recovered. In the long-term, a major reduction in fertiliser costs and improved income leads to increased benefits.

Benefits compared with costs	short-term	long-term
establishment	positive	positive
maintenance/recurrent	positive	positive

Impacts of the technology*

Production and socioeconomic benefits

- +++ Reduced expenses for agrochemicals (fertilisers, pesticides)
- +++ Increased yield
- ++ Allows organic production of high value crops

Production and socioeconomic disadvantages

- --- High establishment costs

Socio-cultural benefits

- + Social prestige as a progressive farmer

Socio-cultural disadvantages

- \- Requires handling of dung and urine

Ecological benefits

- +++ Reduced application of agrochemicals (fertilisers, pesticides), reduced eutrophication, nitrification of water bodies due to uncontrolled outflow of urine

Ecological disadvantages

none

Off-site benefit

- ++ Reduced dependence on costly external inputs
- ++ Reduced influx of nutrients into water bodies

Off-site disadvantages

none

* All changes in technology may have gender and equity implications and potentially affect the members of disadvantaged groups differently. This has not been assessed here but should be considered when recommending technology use.

Concluding statements

Strengths and ➔how to sustain/improve	**Weaknesses** and ➔how to overcome
Urine as a liquid manure is applied at the same time as irrigation (fertigation) ➔ The link between urine application and drip irrigation or other forms of small scale irrigation needs to be promoted	The initial establishment costs for a drip irrigation set may hinder adoption ➔ Prepare a business plan and calculate the cost-benefit to convince farmers of the technology's benefits
The on-farm use of collected urine reduced the need for mineral fertiliser thereby reducing cash expenditure and outside dependency ➔ Further promote the technology to increase this impact	Lack of availability of urine may inhibit the commercial application of urine with drip irrigation ➔Urine needs to be established as a tradeable good produced by livestock farmers and bought by vegetable farmers to apply to their crops
Human urine can also be used, but needs to be fermented longer and may be socially less acceptable ➔Further promote the use of urine and show that there is no problem with using human urine	

Key reference(s): none

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