Managing natural resources through simple and appropriate technological interventions for sustainable mountain development

R. K. Maikhuri, L. S. Rawat, Vikram S. Negi, V. K. Purohit, K. S. Rao and K. G. Saxena*

Poor access to appropriate technologies due to difficult topographies and tough mountain conditions is one of the major causes of poverty, drudgery and natural resources degradation not only in the Indian Central Himalaya, but also in other parts of the Hindu-Kush Himalaya. Of late, development planners have realized the importance of suitable or appropriate technologies and practices, and therefore have stressed upon the need for large-scale demonstration, on-site training, capacity building and skill development of user groups in rural and marginal areas of the region. The Garhwal Unit of G.B. Pant Institute of Himalayan Environment and Development is one among the few organizations in the Indian Himalayan region involved in testing, developing, upgrading, validating and demonstrating appropriate technologies through action and participatory research. As a result of these efforts, a number of farmers and other stakeholders, including NGOs and educational institutions have adopted some of the potential rural technologies at various levels. The technologies preferred and adopted by the farmers include protected cultivation, water-harvesting tank technology, zero-energy cool chamber, bio- and vermi-composting, bioprospecting of wild resources, biobrequetting, mushroom cultivation and sloping watershed environmental engineering technology. It is hoped that the improved capacities of local farmers will help in the widespread adoption of rural technologies in Central Himalaya and other countries in the Hindu-Kush Himalayan region facing common problems/issues and having similar environmental and socio-economic conditions.

Keywords: Capacity building, mountains, natural resources, sustainable development, technological interventions.

THE Himalayan mountain system, spread over eight Asian countries (viz. Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal and Pakistan) and home to 150 million people, is one of the most fragile and complex ecosystems in the world. Yet, India's recognition as a megadiversity country and as one of the 10 most extensively forested areas in the world, derives from the Indian Himalaya region covering only 18% of the country's geographical area, but about 50% of the forest cover and biodiversity[1,2]. People living in this natural resources-rich region happen to be quite poor. Because of limited opportunities of economic development within the region, frustrated youth are migrating in large numbers to the urban and industrial regions in the plains in search of employment[3]. Environmental degradation and poverty are threats to the livelihoods of not only upland people, but also of a much larger population inhabiting the adjoining Indo-Gangetic plains[2,4].

In India, central and state governments have realized the urgency of harnessing the potential of science and technology to overcome the constraints to sustainable development in the fragile Himalayan environment[5,6]. In this regard, the Rural Technology Demonstration and Training Centre (RTDTC) has been perceived as a means of developing and disseminating improving technologies enabling improvement in the yield potential of farms, income generation from off-farm activities, and conservation and efficient use of natural resources in remote, rural hilly areas.

R. K. Maikhuri, L. S. Rawat, Vikram S. Negi are in the G.B. Pant Institute of Himalayan Environment and Development, Garhwal Unit, Srinagar Garhwal 246 174, India; V. K. Purohit is in the High Altitude Plant Physiology Research Centre, H.N.B. Garhwal University, Srinagar Garhwal 246 174, India; K. S. Rao is in the Department of Botany, University of Delhi, Delhi 110 007, India; K. G. Saxena is in the School of Environmental Sciences, Jawaharlal Nehru University, New Delhi 110 067, India.

*For correspondence. (e-mail: rkmaikhuri@rediffmail.com)

Socio-ecological setting of the study area

The Central Himalayan region of India is spread over an area of 53,483 sq. km and is home to around 8.5 million people. A difficult topography, high degree of inaccessibility, poor infrastructural facilities and limited opportunities of income are responsible for poor economic conditions of the majority of local people.

Methodology

Participatory learning and sharing of knowledge was the method adopted during the present field-based programme on development of environmentally sound technologies together with capacity building of local people. Seeking the help of village leaders, 1086 farmers in three villages, viz. Maletha, Tapovan and Triyuginarayan possessing good knowledge, technical skills and keen interest in developing improved technologies were selected for participation in the present programme. Based on the advice of the village council, all beneficiaries were selected from the economically weaker section of the society. Technology development, implementation and evaluation is always a two-way learning process, where experts and local farmers improve their respective capacities and empower themselves so as to move forward from a marginal to a stronger socio-economic position.

Appropriate technologies

The top-down approach of pushing new technologies, often drawn from their success in lowlands, without transfer of adequate knowledge and building capacities of local communities has, by and large, failed to achieve the desired objectives in the past[7,8]. Learning lessons from the past experiences, mountain specificities, such as diversity in livelihood strategies, economic marginalization, isolation, difficult topography, cultural diversity and ecological fragility, were taken into account in identifying appropriate technologies. In addition, a technology was considered simple and appropriate when there were no socio–cultural–economic-policy barriers to its adoption. The bottom-up approach adopted here meant: (i) building technologies on indigenous knowledge, management practices and informal institutions; (ii) supplementing/complementing the people's worldview with the scientific knowledge, (iii) linking indigenous informal and formal environment-development, and (iv) involving people in all stages of technology development, implementation and sustainability evaluation. The technological interventions aimed to improve agricultural productivity through protected cultivation, improved composting and soil/water management practices, value addition to forest/farm products and improved product storage devices[9–12].

Major objectives of the initiative

With the above background, this initiative aimed at: (i) demonstration of improved/alternative hill-specific technologies in RTDTC; (ii) development of a participatory action research approach for securing sustainable livelihoods in the long run, and (iii) capacity building and skill development through training/live demonstrations/field exercise of target groups, and training of trainers on a regular basis by the process of 'learning by doing'. Three RTDTCs were established, one each in Maletha village (560 m asl) in Tehri Garhwal District, Triyuginarayan village (2300 m asl) in Rudraprayag District and Tapovan village (1900 m asl) in Chamoli District, covering a wide range of agro-ecological conditions of Uttarakhand. Twelve potential rural technologies were successfully demonstrated (Table 1) and a total of 35 training programmes were organized to disseminate experiences and build local capacity. All demonstrations were monitored and evaluated to measure their level of success involving farmers.

Process and approach

Before initiating the programme, an in-depth rapid rural appraisal survey was carried out in a cluster of eight villages, including the three selected for establishing RTDTCs. This survey was followed by (i) multi-stakeholder consultations to gather wider perspectives; (ii) analysis of administrative, technical, policy and financial implications of existing livelihood practices, and (iii) visioning of the future sustainability as influenced by new technology interventions. Small group workshops were held to (a) gain an in-depth understanding of technical, socio-economic and environmental perspectives of a given technology; and (b) make farmers understand the importance of scientific data collection/analysis and scientists understand farmers' understanding about environmental conservation, socio-economic development and implementation arrangements required for demonstrating the technologies[13,14]. All technological interventions were aimed to promote natural resources conservation coupled with the enhancement of local livelihoods[3].

The programme facilitated regular interactions among scientists and primary stakeholders during the period 2000–2008, so as to ensure that farmers acquired all necessary knowledge related to a technology. The regular visits of scientists were ensured during field experiments. At the same time, farmers were provided with opportunities to make detailed observations in the field, analyse them, and communicate these observations among themselves and to the scientists in small group discussions. Scientists, field/extension workers, local NGO representatives, officials of Government line departments and knowledgeable farmers were at times invited to these group discussion to exchange knowledge, experiences and vision on wider scale. Thus, the way farmers were trained in the present programme was radically different from the conventional training programmes in which experts merely

Table 1. Brief description about technologies developed and demonstrated in the Rural Technology Demonstration and Training Centres in the Central Himalayan region of India

Technology	Description
Protected cultivation	
Polyhouse	High level of production of vegetables and ornamental flowers is achieved by growing crops under a cover of polythene sheet (150 g thickness), which protects them from severe stresses of low temperature, frost and pathogens causing frequent crop failure in traditional agricultural systems.
Nethouse	High level of production of off-season vegetables and some medicinal plants is achieved by growing crops under a cover of nylon net at lower elevations, where high temperatures coupled with water stress cause crop failure in traditional agricultural systems.
Polypit	Underground pits covered by polythene sheet (150 g) provide better microclimatic conditions to vegetable and ornamental crops compared to those in traditional agricultural systems. Polypits and polyhouses are equally effective, but the former are cheaper than the latter.
Organic compost and biofertilizer	
Biocomposting	Mixture of household organic waste, weed biomass and domestic waste water is composted in small pits, resulting in completion of manure formation over a period of 30–45 days compared to 8–10 months in the traditional manure preparation method. Biocompost is also richer in nutrients compared to traditional manure.
Vermicomposting	*Eisenia foetida*-mediated composting of a mixture of cow dung, forest leaf litter and agricultural residues enables production of manure richer in nutrient content over a shorter period of time compared to traditional and biocomposting technologies.
Vermiwash	Vermiwash, the water leached from a vermicompost column, is highly rich in nutrients and also shows pesticidal effects.
Azolla culture	Seeding of wet paddy fields with *Azolla* results in high crop yield because of recycling of atmospheric nitrogen fixed by *Azolla*.
Off-farm technologies	
Mushroom cultivation	The landless/small holders can earn income by growing edible mushrooms on wheat crop residue-based substrate.
Honey-bee rearing	The landless/small holders can earn income from bee hives made from waste deadwood. Apart from income, honey has traditional medicinal value and bees, being good pollinators, provide ecosystem services.
Bioprospecting of wild/ semi-domesticated fruits	Value is added to wild edible such as *Myrica nagi*, *Rhodendron*, *Rubus ellipticus* and *Hippophae salcifolia* by preserving them in the form of juice, jam and jelly.
Other supporting technologies	
Biobrequetting	Charcoal prepared by combustion of forest litter under low-oxygen conditions is powdered, mixed with clayey soil and water, and small bricks prepared by sun-drying the paste. These bricks constitute a more efficient source of fuel compared to traditional fuel and their use reduces the pressure on forests.
Zero-energy cool chamber	Double-walled chambers (10 cm thick sand column between the two walls) maintain temperatures 8–10°C lower than the ambient atmosphere and thus provide cost-effective and eco-friendly food storage devices.
Water-harvesting tank technology	Storage of run-off in small tanks lined by a polythene sheet and its use for life-saving irrigation in upland rainfed systems increased crop yield and profit by 1.5–2.0 times.
Sloping watershed environmental engineering technology (SWEET)	Soil/water conservation and restoration of a diverse vegetation cover imitating natural forests in degraded lands are designed by capitalizing on the strength of indigenous knowledge and overcoming weaknesses through scientific inputs. The rehabilitation strategy is such that investments are recovered over a period of 5–7 years. Rehabilitation provides direct economic benefits to people along with significant ecosystem services.

delivered lectures and advised farmers to just follow their recommendations. Over a period of eight years of interaction, many farmers were able to raise their analytical capacity to an extent that they were able to discuss short-term and long-term costs and benefits of the present/alternate practices and articulate new ideas in group discussions[13,14]. An assessment of the extent of adoption, usefulness of technology and cost–benefit analysis formed the key elements of the technology monitoring, evaluation and dissemination framework.

Strategic framework for stakeholders training

The progressive farmers directly involved in demonstrations were mobilized to become master trainers for a

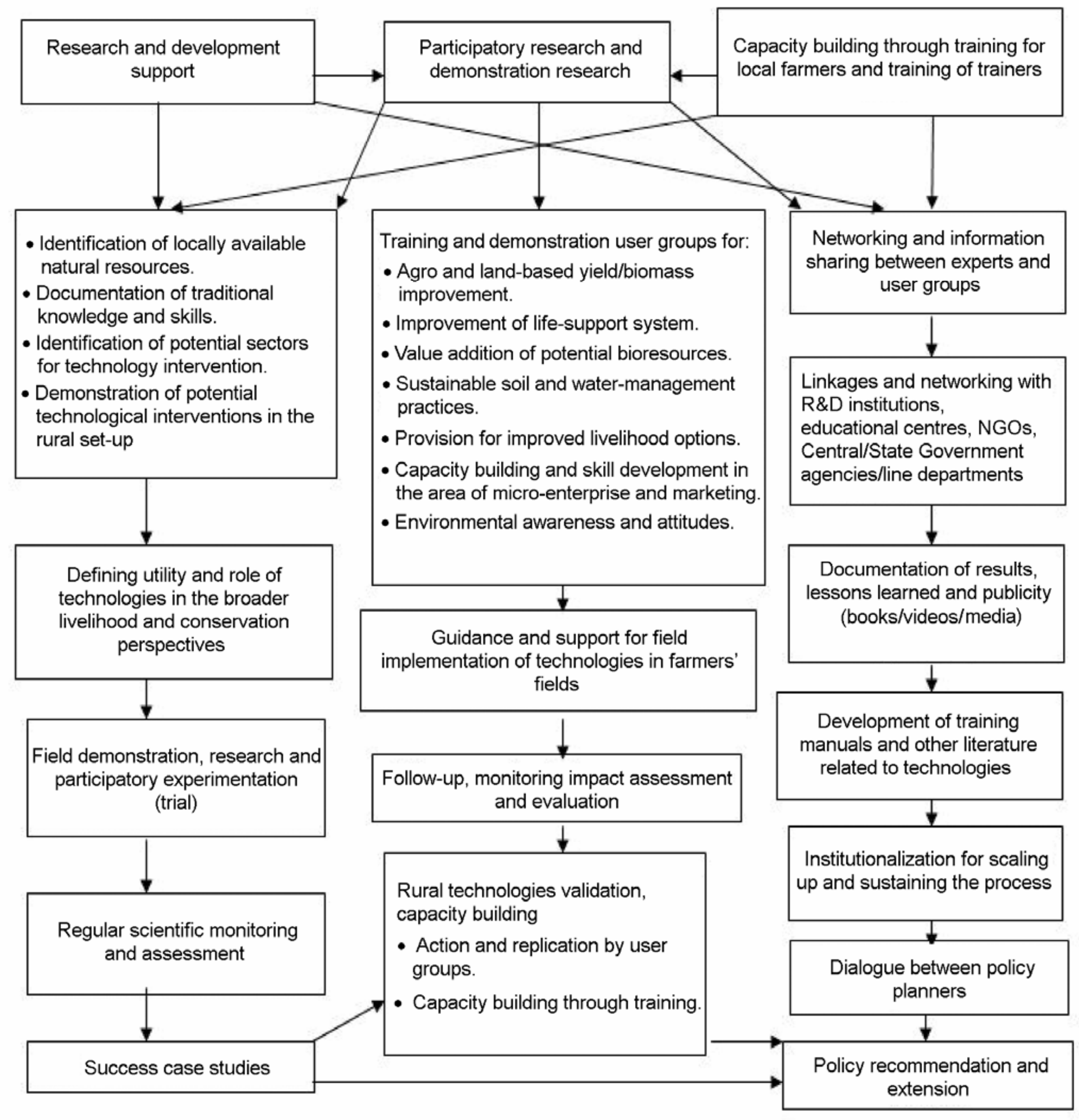

Figure 1. Promoting adoption of simple and appropriate technologies among the user groups through capacity building, participatory research and demonstration.

larger farming community. Training and exposure material was developed both in Hindi and English to reach out to different stakeholders. Though the training programme was conceived mainly to provide technical inputs to local farmers and extension officials, a number of new issues emerged during the course of demonstration which led to further improvements in the demonstrated technologies. Drawing on the experiences and expertise of different disciplines and stakeholders, an integrated framework of technology development and training was formulated to identify the 'best' solution and implementation arrangements (Figure 1). The process of technology transfer was completed in nine steps: (i) site selection, (ii) resources survey, (iii) development of an operational framework, (iv) planning and management of demonstration, (v) crystallizing the specificities of people's participation, (vi) capacity

Table 2. Simple and appropriate technology adoption (number of villages/families where the technologies were adopted; values in parentheses refer to number of families) and income (Rs, mean ± standard error) to hill people

Technology	Extent of adoption	Average size of treatment area/ plant species used	Average income (Rs)/ family/yr
Protected cultivation			
Polyhouse (low-cost)	8 (41)	10 m × 5 m × 2.5 m	4256 ± 185
Nethouse (low-cost)	3 (16)	10 m × 5 m × 2.5 m	3958 ± 135
Organic composting and biofertilizer			
Biocomposting	13 (64)	5 m × 2 m × 1 m	1260 ± 98
Vermicomposting	16 (84)	5 m × 2 m × 1 m	3645 ± 148
Azolla culture	9 (37)	10 m × 2 m × 1 m	842 ± 82
Off-farm technologies			
Mushroom cultivation	15 (78)	120 kg base material*	3856 ± 172
Honey-bee rearing	7 (24)	Single improved wooden box	1578 ± 123
Bioprospecting of wild/semi-domesticated fruit species	15 (75)	Five potential plant species used**	4826 ± 265
Other supporting technologies			
Biobrequetting	11 (39)	1 m × 1 m × 1 m	6845 ± 212
SWEET technology	5 (7)	1 ha	2630 ± 132
Water-harvesting tank	8 (19)	6 m × 3 m × 1.5 m	1443 ± 120
Zero-energy cool chamber	5 (6)	3 m × 1.5 m × 1 m	1130 ± 90

*Wheat straw of about 80 kg was used as raw (base material on dry wt basis) for mushroom cultivation.
***Spondias pinnata*, *Hippophae salicifolia*, *Aegle marmelos*, *Ficus auriculata* and *Rhododendron arboreum*.

building and skill development, (vii) implementation/ adoption, (viii) monitoring and evaluation, and (ix) feedback.

Community outreach, mobilization, adoption and follow-up

A total of 35 training programmes (each of 2–3 days) on rural technologies were organized during 2000–2008 reaching out to 1086 farmers, 280 extension workers, 67 Government officials and 1436 students. The programmes gained wide popularity and created awareness, with many motivated farmers, students, NGOs and Government officials visiting the demonstrations on their own, a large number of farmers, many from outside the demonstration villages, adopting the demonstrated technologies (Table 2) and a few Government organizations including scaling out of demonstrated technologies in their action plans. Yet, a large number of farmers exposed to demonstrations did not replicate technologies on their farms suggesting a need for further improvements in the technologies, and financial and intuitional support in the initial stages of on-farm trials.

Conclusion

The capacity building and outreach programmes in the area of appropriate technologies have made a significant impact in the Himalayan region. However, poor communication and coordination among policy makers, Government agencies, NGOs, researchers and farmers continues to be a major barrier in harnessing the potential of science and technology in meeting the challenges of sustainable mountain development. Conservation/development policies should fully take into account specificities of mountain regions in characterizing a technology as 'appropriate' and establish an enabling environment for adoption of appropriate technologies and improvements there in through joint efforts of the people, researchers, government agencies and NGOs.

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